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Tampa Electric Company proposes to construct and operate a 417 MW (NET) capacity coal-fired electric generating plant at the existing Big Bend complex adjacent to Hillsborough Bay in west-central Hillsborough County, Florida. The EIS examines project alternatives, impacts, and mitigative measures related to groundwater, air, surface water, ecological, and socioeconomic and cultural systems.

Volume I describes the area of interest, discusses power generation alternatives, management and site alternatives and alternative plant systems.

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Chapter 1

BACKGROUND

1.1 IDENTIFICATION OF APPLICANT

The Applicant is Tampa Electric Company (TECO), with headquarters at 111 North Dale Mabry Highway, Tampa, Florida. Incorporated December 1899 and reincorporated in 1949, TECO is a public utility operating wholly within Florida. The company is principally engaged in the generation and sale of electricity. TECO is a member of the Florida Electric Power Coordinating Group (FCG) and actively participates in the coordination, planning, and operation of the Peninsular Florida Electric System.

1.2 PROJECT OBJECTIVES

The objective of the project is to provide an adequate source of electric energy at the time of need. TECO serves an area of nearly 1,900 square miles on the central west coast of Florida, including all of Hillsborough County and parts of Pasco, Pinellas, and Polk Counties. More than 700,000 persons live in these areas. TECO serves approximately 296,000 customers. It has 2,390 employees and 14,000 common shareholders. The TECO service area is shown in Figure 1-1 (Tampa Electric Company 1980).

TECO produces electricity in three wholly owned powerplants located on or near the eastern shores of Tampa Bay. The units in these plants have a generation capability mix of approximately 65 percent coal, 29 percent No. 6 low-sulfur fuel oil, and 6 percent No. 2 low-sulfur fuel oil. The energy produced from these plants has a generation mix of approximately 80 percent coal, 19 percent No. 6 fuel oil, and 1 percent No. 2 fuel oil (System Planning Committee 1979).

Hookers Point Station is the oldest of TECO's three powerplants. It is located just southeast of the Tampa business district on Hookers Point, fronting the Seddon Ship Channel. Hookers Point boilers burn No. 6 low-sulfur fuel oil.

Gannon Station is 6 miles south of Tampa. Its addition to the TECO system began in the 1950s, when Florida's growth was extremely rapid. Six units went into service between 1957 and 1967, and all of them originally burned coal. To comply with environmental requirements, the first four units were converted to No. 6 low-sulfur fuel oil in 1975 and 1976. Units 5 and 6 burn low-sulfur coal. One 14-megawatt gas turbine, which burns No. 2 low-sulfur fuel oil, is also located at Gannon Station. TECO plans to convert the first four units back to coal beginning in 1983.

Big Bend, TECO's newest powerplant, is 10 miles south of Tampa, and is designed to be efficient and to operate in harmony with the environment. Three units are burning coal. One 14-megawatt and two 65-megawatt gas turbines, which burn No. 2 low- sulfur fuel oil, are located just north of Big Bend Station.

Presently, the three TECO powerplants have a total net generating capability of 2,495 megawatts (Tampa Electric Company 1980), as shown in Table 1-1.

TECO is an active participant in the FCG as well as the FCG System Planning Committee. The Peninsular Florida generation reliability study for 1979 indicates that, for the period of 1979 through 1988, the loss-of-load probability (LOLP) for Peninsular Florida ranges from 0.03 d/yr (1979) to 0.18 d/yr (1988), compared to the desired value of 0.1 d/yr (System Planning Committee 1979). (This estimate includes currently planned additions.)

The proposed facility is not planned to be used to meet other objectives, such as the production of steam for resale.

1.3 HISTORICAL AND PROJECTED NEED FOR POWER

In the Site Certification Application, TECO provided three forecast scenarios: low, medium, and high. The medium forecast scenario was the official published forecast. The high and low forecast scenarios represent variations from the medium population projection combined with factors such as decreasing or increasing electricity prices and appliance efficiency standards, and they include reasonable assumptions for the future rather than worst-case considerations.

Recent and projected TECO energy use by user class is shown in Table 1-2. Figure 1-2 presents the same information in graphic form (Tampa Electric Company 1980).

The TECO historical and forecast total peak demands for summer and winter are presented in Figures 1-3 and 1-4. Table 1-3 presents both the total and interruptible peak demands for the same period. Forecasts of capacity, demand, and scheduled maintenance at the time of summer and winter peaks for TECO are shown in Tables 1-4 and 1-5 (Tampa Electric Company 1980).

These forecasts indicate that the average net summer peak will increase about 64 MW/yr for the next 9 years 1980 through 1988. However, the forecast for the increase in the average net winter peak demand over the same period is about 86 MW/yr (Tampa Electric Company 1980). This demonstrates a need for additional generating capacity, and this need can best be met by baseload capacity with the addition of Big Bend 4 in 1985, the realization of a projected joint generating facility in 1989, and power purchases on an interim basis.

A future unit power contract from TECO Big Bend Unit 4 to another utility has been negotiated for the period 1985 through 1987. The capacity assigned to the other utility will not exceed an amount set by TECO. The amounts will be approximately 70 percent (1985), 50 percent (1986), and 25 percent (1987) of the Big Bend Unit 4 capacity.

TECO is pursuing joint ownership for future generation expansion. To meet future baseload requirements, coal and nuclear power will continue to be reviewed to determine the most economical and feasible generation expansion. By using economy of scale, two or more utilities may benefit from joint ownership.

As shown in Table 1-6, TECO has full interchange agreements with Florida Power and Light Company, Florida Power Corporation, and the City of Lakeland. In addition, TECO has economy interchange agreements with Fort Pierce Utilities Authority, Orlando Utilities Commission, and Vero Beach Municipal Utilities. TECO will participate in economy interchange transactions whenever practical and possible.

Table 1-7 presents the 1979 forecast of TECO system capability additions and removals for the period 1980 through 1988 (System Planning Committee 1979). As discussed in the 1979 plan, the TECO 1980 Ten-Year Site Plan does not include the addition of combustion turbines at Big Bend in 1983. The 1980 plans reflect an upgrading of Big Bend Unit 2 by 25 megawatts summer and winter. In addition, the Applicant is planning on participating in a joint-generating 800-megawatt coal-fired unit scheduled for 1989 startup, with TECO retaining approximately 400 megawatts. Also included in Table 1-7 are similar additions and removals by other utilities in the Peninsular Florida Coordinating Group for the same time span.

1.4 RESERVE CAPACITY

System capacity requirements and system reliability are determined by TECO by the LOLP method in conjunction with the General Electric Company Optimized Generation Planning (OGP) Program. The LOLP method combines a probabilistic capacity model with a model of daily peak-hour loads to determine the number of days per year when generation will be insufficient to meet firm load. The accepted desired value for loss of load is 0.1 d/yr. Firm load is defined as the total system load less the interruptible load. Only those customers who are receiving an interruptible rate and whose service can be directly interrupted are included as interruptible load. The historical and projected interruptible loads for TECO during summer and winter peaks are shown in Table 1-3.

The single area calculation of LOLP considers all loads and generators of a system to be on the same electrical bus. The transmission system effects are not modeled in this calculation. The LOLP method does not give any weight to the amount or duration of the capacity shortage but only to the fact that there is a certain probability of having some capacity shortage during the peak hours of the day.

TECO has an obligation to contribute its fair share of the generating additions to maintain the reliability of the Peninsular Florida system. TECO evaluates its reliance on the Peninsular Florida generating system and its interconnections periodically with the use of the probability studies previously discussed. Major objectives are to maximize the benefits of joint operation, to minimize the effects of generation outages associated with the functioning of a large electric power supply system, and to contribute a fair share to the ensurance of system reliability. The TECO fair share is determined through an evaluation of its reliance upon the Peninsular Florida generation and interconnection system. According to the TECO Site Certification Application (Tampa Electric Company 1979), the 1978-1979 total system winter peak demand for TECO is 10.5 percent of the total system peak of Peninsular Florida.

Tables 1-4 and 1-5 show the projected reserve margin for TECO, together with the impact of scheduled maintenance. Maintenance forecasts are manual (i.e., not computer assisted) for the first 2 years of the 10-year forecast period. Beginning with the third year, however, the maintenance schedule is estimated using a computer program that levels out risk.

Table 1-8 shows the effect on the TECO system reserves of postponement of the inservice date of Big Bend Unit 4; the firm-load winter reserves for 1985-1986 would drop to 9 percent from the projected 26 percent.

The impact of a 1-year delay of all Peninsular Florida baseloaded plants scheduled for service from 1983 to 1988 is shown in Figure 1-5. There is a significant shift in the level of reliability, with LOLP increasing by a factor of 2 to 7, depending on the characteristics of the unit and how many units are delayed each year (Tampa Electric Company 1979).

Should TECO experience a capacity deficiency, a plan would be implemented that would reduce the load through priority assignments and ensure system stability. This is a short-term plan, however, and not a substitute for good system reliability planning.

The plan, beginning with the curtailment of the interruptible load, is frequently implemented in varying degrees. The latter phases of the plan, involving the curtailment of firm load, have been required only on very rare occasions. A snowfall in Tampa on January 18, 1977, is an example.

1.5 ELECTRICAL DEMAND FORECAST METHODOLOGY EMPLOYED BY APPLICANT

TECO forecasts its requirements for both demand and energy by three independent methodologies. The results of these three methodologies are compared and one final forecast prepared. The methods used are trend analysis, detailed end-use modeling, and multivariate demand modeling. This integrated approach is shown in Figure 1-6. While TECO has used trend analysis in forecasting for many years, similar application of the detailed end-use model is new. The results of these two projection approaches are very similar for the period 1979 through 1988, as shown in Figure 1-7 (System Planning Committee 1979). The demand for the phosphate industry is separately projected. The 1980-1990 Demand and Energy Forecast also considers new technologies such as electric vehicles, load management, solar heating and cooling equipment, and conservation.

1.5.1 TREND ANALYSIS

Trend analysis had been used extensively in the past, and it worked well until the oil embargo of 1973. Since 1973, there have been some difficulties in applying the trend analysis or curve-fitting technique because of an inconsistent trend line. Traditionally, the utility industry has correlated total energy sales to the years the sales were made. A forecast was made simply by substituting a future year into the resulting curve-fitted equation. The trend technique can be modified by examining different time intervals (staggered or overlapping) to produce different equations.

The results of the trend technique, when compared and augmented with subjective reasoning and a knowledge of historical growth patterns, can produce a forecast that may not necessarily follow a specific curve. Judgment and the analysis of growth patterns have been added to the forecast technique because of the unpredictable nature of energy use over the past few years. Forecast categories that TECO projected with the trend method include the following:

- Residential customers
- Street and highway lighting energy sales
- Energy sales to public authorities
- Small light and power energy sales
- Large light and power energy sales
- Average use per customer

The residential energy sales were derived by multiplying projections of the number of residential customers by the average energy use per customer. Both the small and large light and power energy estimates were made by identifying and extrapolating certain historical relationships between the two energy classes. Miscellaneous sales were based on a simple trend line of historical data. The forecasts of phosphate demand and of energy sales to the phosphate industry require a detailed knowledge of phosphate industry operations. The energy sales projection is prepared separately from other industrial-use projections. The total energy sales projection is made by a combination of these individual projections. The peak demand forecast is made by combining total sales with an estimate of the system load factor, which is expected to decrease slightly.

1.5.2 DETAILED END-USE MODEL

The detailed end-use load-forecasting model used by TECO is based on a method developed by Battelle Memorial Institute. The method involves dividing the customers into numerous end-use categories and then simply multiplying the number of users in a category by the average customer consumption in that category to obtain electricity use for that category. The TECO model is divided into residential, commercial, industrial, and miscellaneous customers. The model forecasts annual energy consumption for the total service area and simulates load profiles by end use for typical and extreme days (Tampa Electric Company 1980).

For the residential submodel, the number of users refers to the basic household appliances, which include the following:

- Electric range
- Refrigerator (frost-free)
- Refrigerator (standard)
- Freezer (frost-free)
- Freezer (standard)
- Dishwasher
- Clothes washer
- Electric dryer
- Electric water heater
- Microwave oven
- TV (color)
- TV (black/white)
- Lighting
- Room air conditioner
- Central air conditioner
- Electric space heating

The total residential energy consumption is then the summation of all individual appliance consumption estimates plus the estimate for miscellaneous appliances (i.e., those electric appliances not explicitly recognized).

The commercial power submodel is used to project the electric energy consumption of those customers primarily in the service sector of the economy. Electricity consumption in the service sector is largely determined by the economic activity in the service area and is directly measurable in terms of employment in the service sector. The commercial energy intensiveness or kilowatt-hours per employer in the commercial sector was derived from historical data (1967 to 1975) on energy consumption and number of employees.

The industrial submodel is divided into four subsectors: food products; tobacco and printing, etc.; fabricated metals, etc.; and basic industries. The components (Standard Industrial Classification number) of each subsector have similar energy consumption per unit of economic activity. Employment in the industrial sector is also used as an indicator of electricity consumption (energy use per employee) because of the ready availability of employment data and projections. As discussed above, the phosphate industry energy projections are determined independently.

The detailed end-use model is based on a basic equation that applies to all end uses. In its most general form, this equation is written as follows:

$$D_{ij} = N_i C_i F_{ij} \tag{1-1}$$

where

D_{ij} = demand at hour; by end-use component i

N_i = number of use components of type i

C_i = connected load per use component of type i

F_{ij} = fraction of the connected load of use component i that is operating at hour j

The energy consumption for any period is calculated by summing over the corresponding demand values, as follows:

$$E_i = \sum_j D_{ij} \tag{1-2}$$

where E_i is the energy consumption by use of component i for a specific period. The total demand is obtained by summing over all use components operating during the period of interest.

A fundamental factor in the use of this model is the development of the use factors F_{ij}. This is accomplished by providing for four types of days per month: Sunday, Monday, Tuesday through Friday, and Saturday. Thus, the use matrix is dimensioned by type of day, hour of the day, and month of the year. For temperature-sensitive loads, the month is replaced by temperature. The matrix then consists of the probability that the temperature will be between two values (32 and 34°F, for example) during each hour of the day of the month of interest (June or January). The probabilities for any given hour summed over the temperature increments must equal unity.

In order to project a peak day, it is necessary to select an option that derives a warmer or colder than average day. The extent to which the temperature profile for the peak day deviates from the average or most likely day depends on the risk one is willing to take; that is, should the temperature profile have a frequency of occurrence of once in 5 years, in 10 years, or in 20 years. The bases of the peak-load analysis are a design day and the temperature profile for that day. Design days have been established for June and January.

The temperature-sensitive load factors were derived for heating and cooling from the 1970-1977 demand data. The average temperature-sensitive demand was calculated by TECO using energy equations for heating and cooling in the commercial and residential sectors based on the actual average temperature of the peak and preceding day. Because the resulting load factors showed no trend with time, the averages for 8 historical years were used.

A comparison of the total energy sales projections using the detailed end-use model and trend analysis is shown in Figure 1-7. The two forecasts are similar for the 1978-1988 forecast period. This information was prepared for TECO for the 1978-1988 Demand and Energy Forecast published in October 1978.

Figures 1-8 and 1-9 show the actual load profiles and model results for two peak days in 1978, one in January and one in June (Tampa Electric Company 1980).

1.5.3 MULTIVARIATE DEMAND MODEL*

The TECO multivariate demand model consists of three regression equations for load other than phosphate. One equation is for baseload (that portion of the load independent of temperature), the second is for summer temperature-sensitive demand, and the third is for winter temperature-sensitive demand. The regression equations are based on such variables as number of customers, weather (average 24-hour temperature), appliance saturation (air conditioning and heating), and the price of electricity relative to that of other goods and services. The customer forecast has been made using population projections from the University of Florida.

The forecast methodology includes analyses of population forecasts, statistical estimation of the type of weather at the time of peak, air conditioning and heating appliance saturation, and the price of electricity relative to that of other goods and services.

Projections of winter total system load through 1987 according to both the detailed end-use model and the multivariate model are shown in Figure 1-10. The detailed end-use model shows a decrease in growth after 1980 because of appliance efficiency standards that take effect in that period. The multivariate model does not consider appliance efficiency.

1.5.4 PHOSPHATE DEMAND AND ENERGY FORECAST*

The phosphate demand and energy forecast requires an intimate knowledge of the phosphate industry. Some of the primary ingredients in preparing the forecast are as follows:

1. Knowledge of expansion/closeout plans for mining, furnaces, and chemical plants
2. Familiarity with historical and projected industry trends
3. Close working relationships with key phosphate personnel
4. Awareness of past and future government legislation affecting the industry
5. Familiarity with the worldwide demand for phosphate products
6. Knowledge of geologic limitations of the industry in the TECO service area
7. Correlation of electric energy consumption with the historical activity of the industry

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*Tampa Electric Company (1980).

1.6 SUMMARY

Tampa Electric Company serves the central west coast of Florida as a member of the FCG and actively participates in the coordination, planning, and operation of the Peninsular Florida electric system.

Big Bend 4 is the latest unit to be added to the TECO system to satisfy the need for added capacity to meet increasing demands. While industrial consumption is currently about 23 percent higher than the residential consumption (1979), the difference is expected to drop to 18 percent by 1985 and to only 10 percent by 1989 (Table 1-2). The total sales to ultimate customers are also projected to increase from 10,141 gigawatt-hours in 1979 to 11,891 in 1985 and to 12,980 in 1989.

The TECO reserve with Big Bend 4 operating is projected to be in the 20-25 percent range in the late 1980s. Without this unit the reserve would drop to 3-9 percent despite the importation of several hundred megawatts of capacity during the same time span (Table 1-8). The guideline for reserve capacity is usually about 25-30 percent for an individual system such as that operated by TECO.

TECO is an active participant in the FCG. The TECO Site Certification Application indicates that the 1978-1979 total system winter peak demand for TECO is about 10.5 percent of the total system peak for Peninsular Florida. The latest (1979) Peninsular Florida Generation Reliability Study indicates that, for the period 1979 through 1988, the LOLP for Peninsular Florida will range from 0.03 d/yr (1979) to 0.18 d/yr (1988), as compared to the desired value of 0.1 d/yr. If the baseload additions to Peninsular Florida are delayed by a year, the LOLP will increase to more than 0.7 d/yr in 1987, as shown in Figure 1-5. Data on the effect of a delay in the startup of individual units on Peninsular Florida LOLP are not available.

Table 1-1. Tampa Electric Company system net capabilities, December 31, 1979[a]

Item	Type	Capability (MW) Summer	Capability (MW) Winter
Gannon			
1	F	98	98
2	F	108	108
3	F	150	150
4	F	169	169
5	F	214	214
6	F	337	337
1	CT	14	14
Hookers Point			
1	F	29	29
2	F	29	29
3	F	29	29
4	F	43	43
5	F	67	67
Big Bend			
1	F	367	367
2	F	337	337
3	F	360	360
1	CT	14	14
2&3	CT	130	130
Total		2,495	2,495

Abbreviations:
F = fossil.
CT = combustion turbine.

[a] From Tampa Electric Company (1980).

Table 1-2. History and forecast of energy use for Tampa Electric Company[a,b]

Year	Rural and residential	Commercial	Industrial	Street and highway lighting	Other sales to ultimate consumers	Total sales to ultimate consumers	Sales for resale[c]	Utility use and losses	Net energy for load
1970	2,019	1,041	2,772	29	313	6,174	0	368	6,542
1971	2,200	1,166	2,718	30	367	6,481	0	365	6,846
1972	2,416	1,335	2,784	32	402	6,969	0	460	7,429
1973	2,843	1,525	3,004	35	436	7,843	0	448	8,291
1974	2,828	1,640	3,102	33	429	8,032	0	453	8,485
1975	2,906	1,767	3,297	32	467	8,469	0	546	9,015
1976	2,911	1,804	3,564	35	487	8,801	0	492	9,293
1977	3,139	1,904	4,008	35	516	9,602	0	526	10,128
1978	3,313	2,030	4,080	36	576	10,035	0	461	10,496
1979	3,325	2,084	4,101	37	595	10,141	0	583	10,724
1980	3,470	2,181	4,142	37	619	10,449	0	596	11,045
1981	3,556	2,252	4,333	38	639	10,818	0	618	11,436
1982	3,643	2,326	4,455	39	659	11,122	0	635	11,757
1983	3,734	2,401	4,571	39	681	11,426	0	652	12,078
1984	3,827	2,479	4,607	40	703	11,656	0	665	12,321
1985	3,921	2,560	4,643	41	726	11,891	0	679	12,570
1986	4,019	2,642	4,682	42	749	12,134	0	693	12,827
1987	4,118	2,728	4,721	43	774	12,384	0	707	13,091
1988	4,237	2,828	4,767	43	802	12,677	0	724	13,401
1989	4,360	2,930	4,815	44	831	12,980	0	741	13,721

[a] From Tampa Electric Company (1980).
[b] Status as of December 31, 1979.
[c] To Class III and Class V systems.

Note: All values in GWh.

Table 1-3. History and forecast of seasonal peak demand and annual energy requirements for Tampa Electric Company[a,b]

Year	Summer peak demand (net MW)		Net energy for load (GWh)	Load factor[c] (%)	Year	Winter peak demand (net MW)	
	Interruptible	Total				Interruptible	Total
1970	165	1,098	6,542	68.0	1970-71	150	1,105
1971	178	1,194	6,846	65.5	1971-72	142	1,110
1972	145	1,302	7,429	65.0	1972-73	171	1,300
1973	139	1,441	8,291	65.7	1973-74	152	1,366
1974	146	1,527	8,485	63.4	1974-75	155	1,458
1975	147	1,565	9,015	65.8	1975-76	155	1,693
1976	134	1,568	9,293	67.5	1976-77	178	1,784
1977	193	1,720	10,128	67.2	1977-78	206	1,891
1978	169	1,780	10,496	67.3	1978-79	175	1,988
1979	182	1,805	10,724	67.8	1979-80	194	2,007
1980	212	1,860	11,045	67.8	1980-81	196	2,047
1981	216	1,920	11,436	68.0	1981-82	197	2,122
1982	220	1,984	11,757	67.6	1982-83	197	2,199
1983	225	2,064	12,078	66.8	1983-84	197	2,284
1984	225	2,124	12,321	66.2	1984-85	197	2,362
1985	225	2,188	12,570	65.6	1985-86	197	2,448
1986	225	2,247	12,827	65.2	1986-87	197	2,537
1987	225	2,309	13,091	64.7	1987-88	197	2,630
1988	225	2,372	13,401	64.5	1988-89	197	2,726
1989	225	2,439	13,721	64.2	1989-90	197	2,825

[a] From Tampa Electric Company (1979, 1980).
[b] Status as of December 31, 1979.
[c] Based on summer peak.

Table 1-4. Forecast of capacity, demand, and scheduled maintenance during summer peak for Tampa Electric Company[a],[b]

Year	Total installed capacity (MW)	Firm capacity import (MW)	Total available capacity (MW)	Peak demand (MW)	Margin before maintenance		Scheduled maintenance (MW)	Margin after maintenance	
					MW	Percent of peak		MW	Percent of peak
1980	2,495	--	2,495	1,860	635	34	367	268	14
1981	2,520	--	2,520	1,920	600	31	367	233	12
1982	2,520	--	2,520	1,984	536	27	367	169	9
1983	2,520	350	2,870	2,064	806	39	367	439	21
1984	2,520	350	2,870	2,124	746	35	367	379	18
1985	2,937	58	2,995	2,188	807	37	--	--	--
1986	2,937	142	3,079	2,247	832	37	--	--	--
1987	2,937	246	3,183	2,309	878	38	--	--	--
1988	2,937	350	3,287	2,372	915	39	--	--	--
1989	3,337	--	3,337	2,439	898	37	--	--	--

[a] From Tampa Electric Company (1980).
[b] Status as of December 31, 1979.

Note: Capacity changes must be made by May 31 to be considered in effect at the time of the summer peak. All MW values are summer net MW.

Table 1-5. Projected capacity, demand, and scheduled maintenance during winter peak for Tampa Electric Company[a,b]

Year	Total installed capacity (MW)	Firm capacity import (MW)	Total available capacity (MW)	Peak demand (MW)	Margin before maintenance		Scheduled maintenance (MW)	Margin after maintenance	
					MW	Percent of peak		MW	Percent of peak
1980-81	2,495	—	2,495	2,047	448	22	137	311	15
1981-82	2,520	--	2,520	2,122	398	19	137	261	12
1982-83	2,520	—	2,520	2,199	321	15	137	184	8
1983-84	2,520	350	2,870	2,284	586	26	137	449	20
1984-85	2,520	350	2,870	2,362	508	22	137	371	16
1985-86	2,937	142	3,079	2,448	631	26	--	—	--
1986-87	2,937	246	3,183	2,537	646	25	—	—	—
1987-88	2,937	350	3,287	2,630	657	25	--	—	—
1988-89	2,937	350	3,287	2,726	561	21	—	—	—
1989-90	3,337	--	3,337	2,825	512	18	--	--	--

[a] From Tampa Electric Company (1980).
[b] Status as of December 31, 1979.

Note: Capacity changes must be made by November 30 to be considered in effect at the time of the winter peak. All MW values are winter net MW.

Table 1-6. Tampa Electric Company interties[a]

TECO substation	Utility substation	Rating (kV)
Florida Power Corporation		
1. Dade City	Zephyrhills	69
2. Dade City	Brooksville	69
3. Orchid Springs	Lake Wales	69
4. Pebble Dale	Fort Meade	69
5. Sheldon Road	Denham	69
6. Double Branon	Higgins	115
7. South Eloise	West Lake Wales	230
8. Pebble Dale	Fort Meade	230
9. Sheldon Road	Lake Tarpon	230
10. Sheldon Road	Lake Tarpon	230
11. Pebble Dale[b]	Barcola	230
Florida Power & Light Company		
1. Big Bend	Ringling	230
2. Big Bend	Manatee	230
City of Lakeland		
1. Ariana	Larsen Plant	69
2. Sandhill	Highland City	69

[a] From Tampa Electric Company (1979).
[b] Replaces No. 8 in 1982.

Table 1-7. System capability additions and reductions for Tampa Electric Company and other Peninsular Florida Coordinating Group utilities, 1980-1988[a,b] (Sheet 1 of 4)

Year	Utility	Plant	Type	Tampa Electric Company		Peninsular Florida[c]	
				Summer	Winter	Summer	Winter
1980	FPC	Crystal River 2	FC	--	--	50	50
	JEA	Kennedy 6	CT	--	--	54	54
	FPL	Martin 1	FO	--	--	775	775
	FPC	Suwannee P1	CT	--	--	51	51
	FPC	Suwannee P2	CT	--	--	51	51
	FPC	Suwannee P3	CT	--	--	51	51
	HST	IVEY 20	DIE	--	--	7	7
	HST	IVEY 21	DIE	--	--	7	7
	Total			2,495	2,495	23,366.1	26,230.7
1981	FPL	Martin 2	FO	--	--	775	775
	FPC	Suwannee P4	CT	--	--	51	51
	FPC	Simple Cycle A1	CT	--	--	50	50
	FPC	Simple Cycle A2	CT	--	--	50	50
	FPC	Simple Cycle A3	CT	--	--	50	50
	GVL	Deerhaven 2	FC	--	--	235	235
	LAK	McIntosh 3	FC	--	--	334	334
	GVL	J. R. Kelly 6	FO	--	--	(14)	(14)
	Total			2,495	2,495	24,897.1	27,761.9

Note: See abbreviations and footnotes at end of table.

Table 1-7. System capability additions and reductions for Tampa Electric Company and other Peninsular Florida Coordinating Group utilities, 1980-1988[a,b] (Sheet 2 of 4)

Year	Utility	Plant	Type	Tampa Electric Company		Peninsular Florida[c]	
				Summer	Winter	Summer	Winter
1982	FPC	Crystal River 4	FC	--	--	640	640
	OUC	Lake Highland 1	FO	--	--	(30)	(31)
	OUC	Lake Highland 2	FO	--	--	(30)	(31)
	OUC	Lake Highland 3	FO	--	--	(30)	(31)
	Total			--	--	25,447.1	28,308.9
1983	FPL	St. Lucie 2	NUC	--	--	747	747
	SEC	Seminole 1	FC	--	--	600	600
	FPC	Simple Cycle B1	CT	--	--	50	50
	FPC	Simple Cycle B2	CT	--	--	50	50
	FPC	Simple Cycle C1	CT	--	--	100	100
	TEC	Big Bend 4-5	CT	100	100	100	100
	FTP	King 5	FO	--	--	(7)	(7)
	LAK	Larsen 4	FO	--	--	(19)	(19)
	Total			2,595	2,595	27,068.1	29,929.9
1984	FPC	Crystal River 5	FC	--	--	640	640
	TEC	Big Bend GT 6&7	CT	100	100	100	100
	TAL	Purdon 1, 3, 4	FO	--	--	(28.4)	(31.6)
	Total			2,695	2,695	27,779.7	30,638.3

Note: See abbreviations and footnotes at end of table.

Table 1-7. System capability additions and reductions for Tampa Electric Company and other Peninsular Florida Coordinating Group utilities, 1980-1988[a,b] (Sheet 3 of 4)

Year	Utility	Plant	Type	Tampa Electric Company		Peninsular Florida[c]	
				Summer	Winter	Summer	Winter
1985	FPL	Martin Coal 1	FC	--	--	700	700
	FPC	Unknown 1	FC	--	--	660	660
	TEC	Big Bend 4	FC	417	417	417	417
	SEC	Seminole 2	FC	--	--	600	600
	FPC	Avon Park 2	FO	--	--	(42)	(44)
	TAL	Hopkins 3	CT	--	--	50	50
	JEA	Unknown 1, 2, 3	CT	--	--	150	150
	Total			3,112	3,112	30,314.7	33,171.3
1986	LWV	Smith 1	FO	--	--	(7)	(8)
	JEA	Unknown 4, 5, 6	CT	--	--	150	150
	OUC	Lake Highland 1	CT	--	--	(30)	(31)
	OUC	Lake Highland 2	CT	--	--	(30)	(31)
	FPC	Suwanee 1-2	FO	--	--	(67)	(67)
	Total			3,112	3,112	30,330.7	33,184.3

Note: See abbreviations and footnotes at end of table.

Table 1-7. System capability additions and reductions for Tampa Electric Company and other Peninsular Florida Coordinating Group utilities, 1980-1988[a],[b] (Sheet 4 of 4)

Year	Utility	Plant	Type	Tampa Electric Company Summer	Tampa Electric Company Winter	Peninsular Florida[c] Summer	Peninsular Florida[c] Winter
1987	JEA	Joint Coal 1	FC	--	--	600	600
	FPL	Martin Coal 2	FC	--	--	700	700
	FPC	Unknown 2	FC	--	--	660	660
	OUC	Unknown 1	FC	--	--	400	400
	TAL	Unknown 1	FC	--	--	200	200
	Total			3,112	3,112	32,890.7	35,744.3
1988	FTP	King 6	FO	--	--	(18)	(18)
	LWV	Smith 2	FO	--	--	(7)	(8)
	LAK	Larsen 1	CT	--	--	(11)	(13)
	LAK	Larsen 2	CT	--	--	(11)	(13)
	LAK	Larsen 3	CT	--	--	(11)	(13)
	Total			3,112	3,112	32,832.7	35,679.3

Abbreviations:
FPC = Florida Power Corporation.
JEA = Jacksonville Electric Authority.
FPL = Florida Power and Light Company.
HST = City of Homestead.
GVL = Gainesville/Alachua County Regional Utilities Board.
LAK = City of Lakeland.
OUC = Orlando Utility Commission.
SEC = Seminole Electric Cooperative.
TEC = Tampa Electric Company.
FTP = Fort Pierce Utilities Authority.
TAL = City of Tallahassee.
LWU = Lake Worth Utilities.
FC = fossil coal.
CT = combustion turbine.
FO = fossil oil.
DIE = diesel.
NUC = nuclear.

[a] From System Planning Committee (1979).
[b] All data in MW.
[c] Reductions in capability indicated by figures in parentheses.

Table 1-8. Ten-year forecasts of capacity and demand during summer and winter peaks for Tampa Electric Company[a]

Year	Peak demand[b] (MW)	Capacity with Big Bend 4			Margin with Big Bend 4		Margin without Big Bend 4	
		Total installed capacity[b] (MW)	Firm capacity import[b] (MW)	Total available capacity[b] (MW)	MW	Percent of peak	MW	Percent of peak
Summer forecast								
1980	1,860	2,495	--	2,495	635	34	--	--
1981	1,920	2,520	--	2,520	600	31	--	--
1982	1,984	2,520	--	2,520	536	27	--	--
1983	2,064	2,520	350	2,870	806	39	--	--
1984	2,124	2,520	350	2,870	746	35	--	--
1985	2,188	2,937	58	2,995	807	37	390	18
1986	2,247	2,937	142	3,079	832	37	415	18
1987	2,309	2,937	246	3,183	878	38	457	20
1988	2,372	2,937	350	3,287	915	39	498	21
1989	2,439	3,337	--	3,337	898	37	481	20
Winter forecast								
1980-81	2,047	2,495	--	2,495	448	22	--	--
1981-82	2,122	2,520	--	2,520	398	19	--	--
1982-83	2,199	2,520	--	2,520	321	15	--	--
1983-84	2,284	2,520	350	2,870	586	26	--	--
1984-85	2,362	2,520	350	2,870	508	22	--	--
1985-86	2,448	2,937	142	3,079	631	26	214	9
1986-87	2,537	2,937	246	3,183	646	25	229	9
1987-88	2,630	2,937	350	3,287	657	25	240	9
1988-89	2,726	2,937	350	3,287	561	21	144	5
1989-90	2,825	3,337	--	3,337	512	18	95	3

[a] Status as of December 31, 1979.
[b] From Tampa Electric Company (1980).

Note: Capacity changes must be made by November 30 to be considered in effect at the time of the winter peak. All MW values are net MW.

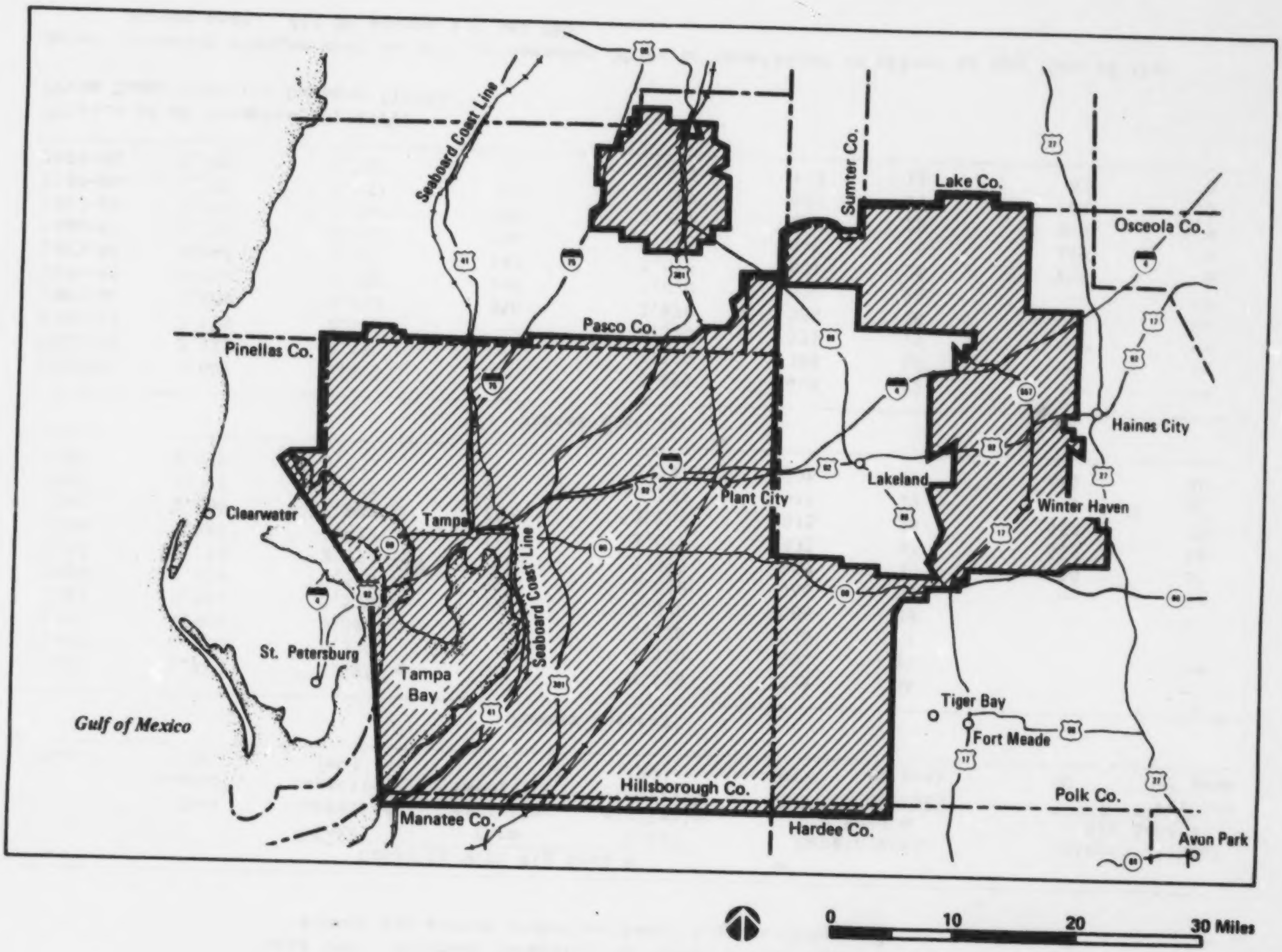
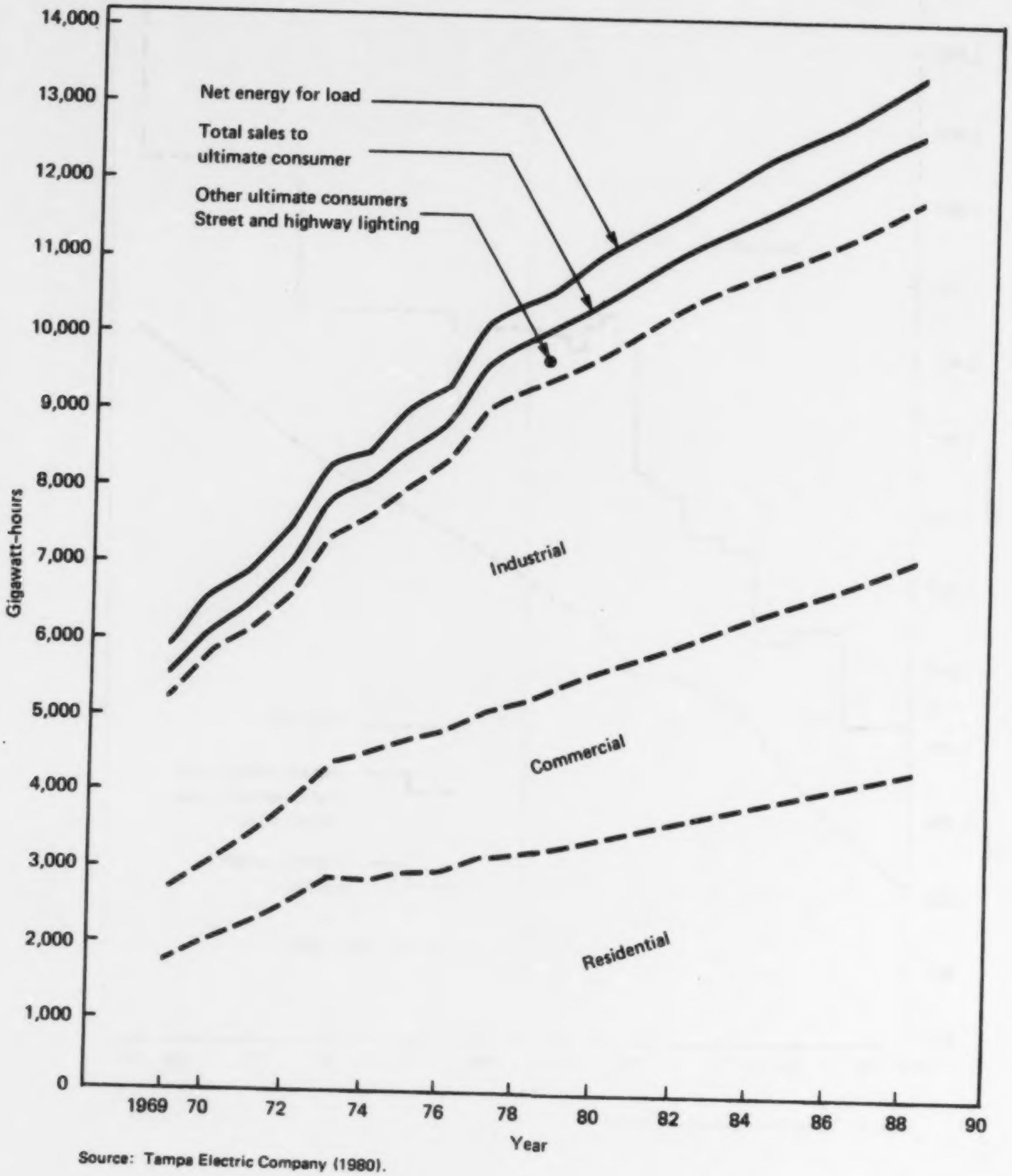
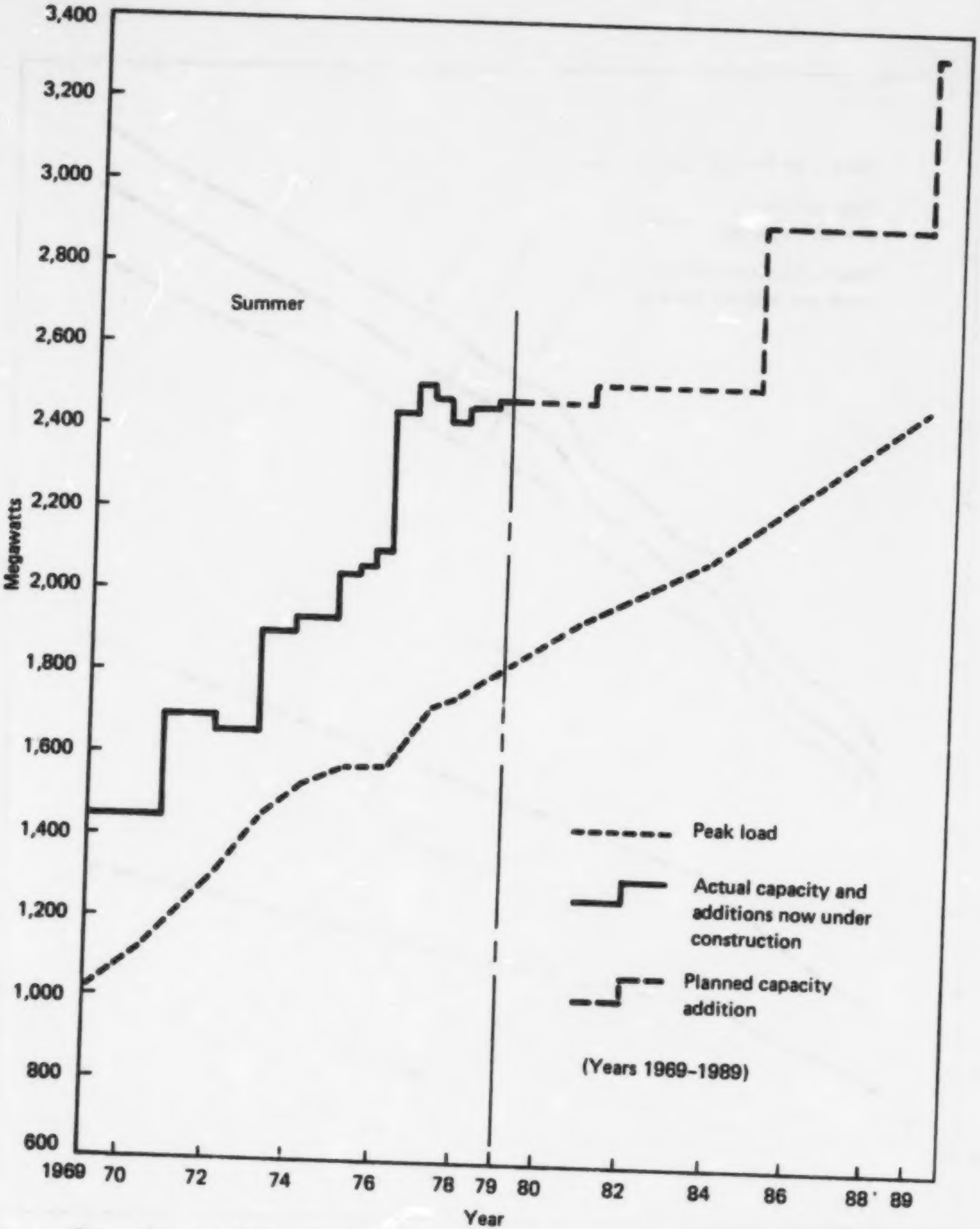

Seaboard Coast Line
Sumter Co.
Lake Co.
Osceola Co.
Pasco Co.
Pinellas Co.
Haines City
Lakeland
Plant City
Winter Haven
Clearwater
Tampa
Seaboard Coast Line
St. Petersburg
Tampa Bay
Gulf of Mexico
Tiger Bay
Fort Meade
Hillsborough Co.
Polk Co.
Manatee Co.
Hardee Co.
Avon Park
0
10
20
30 Miles

Figure 1-1. Tampa Electric Company service area.



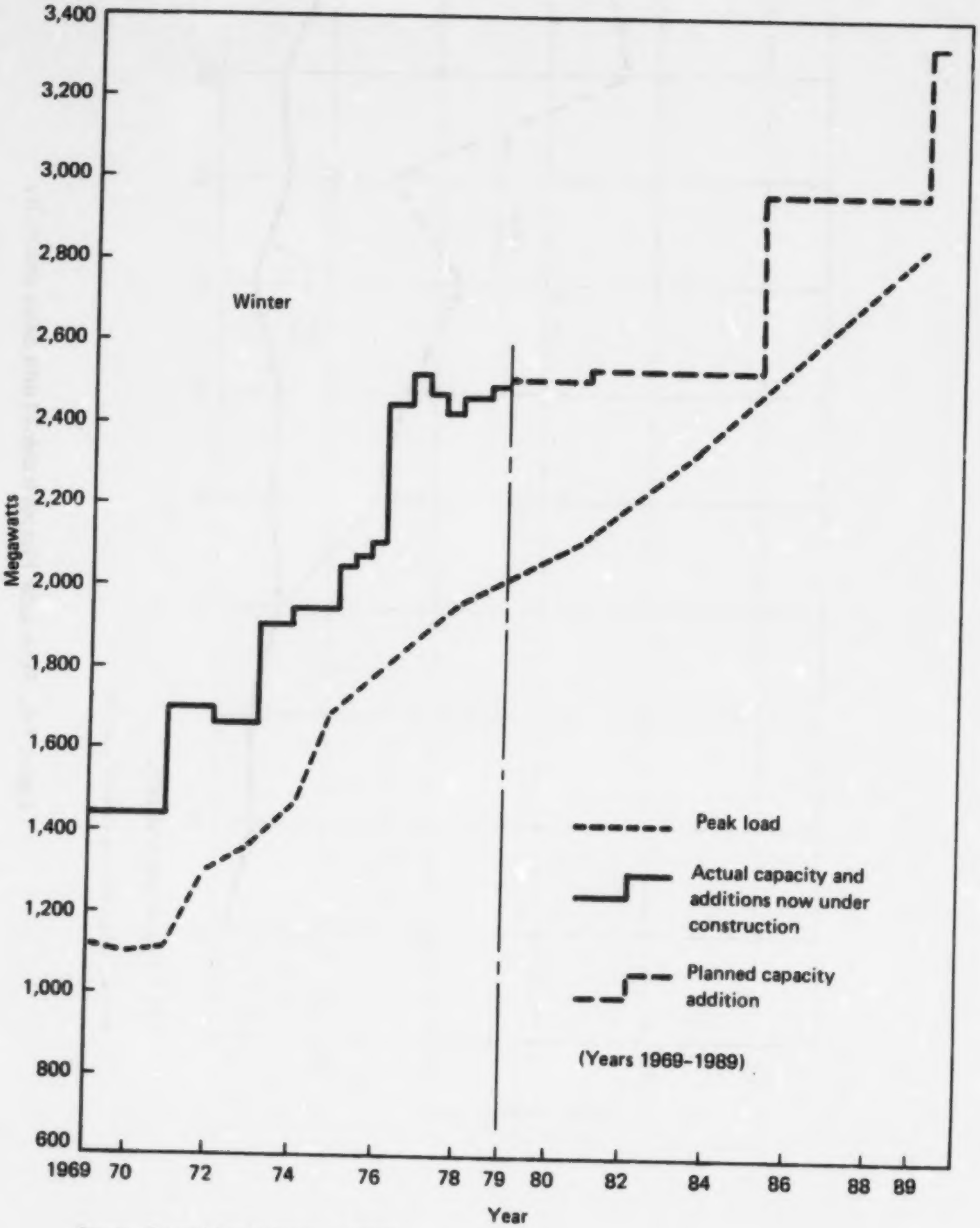
Source: Tampa Electric Company (1980).

Figure 1-2. Historical and projected energy use, Tampa Electric Company.



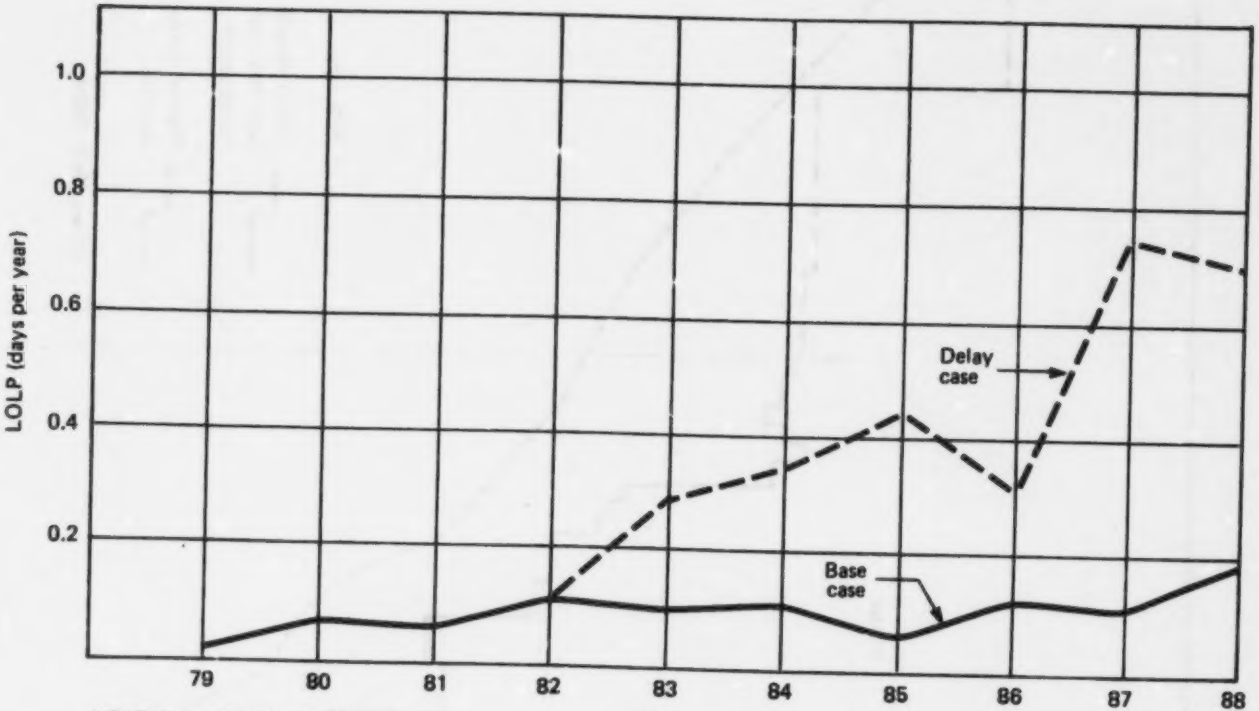
Source: Tampa Electric Company (1980).

Figure 1-3. History and forecast of load and capacity additions for summer, Tampa Electric Company.



Source: Tampa Electric Company (1980).

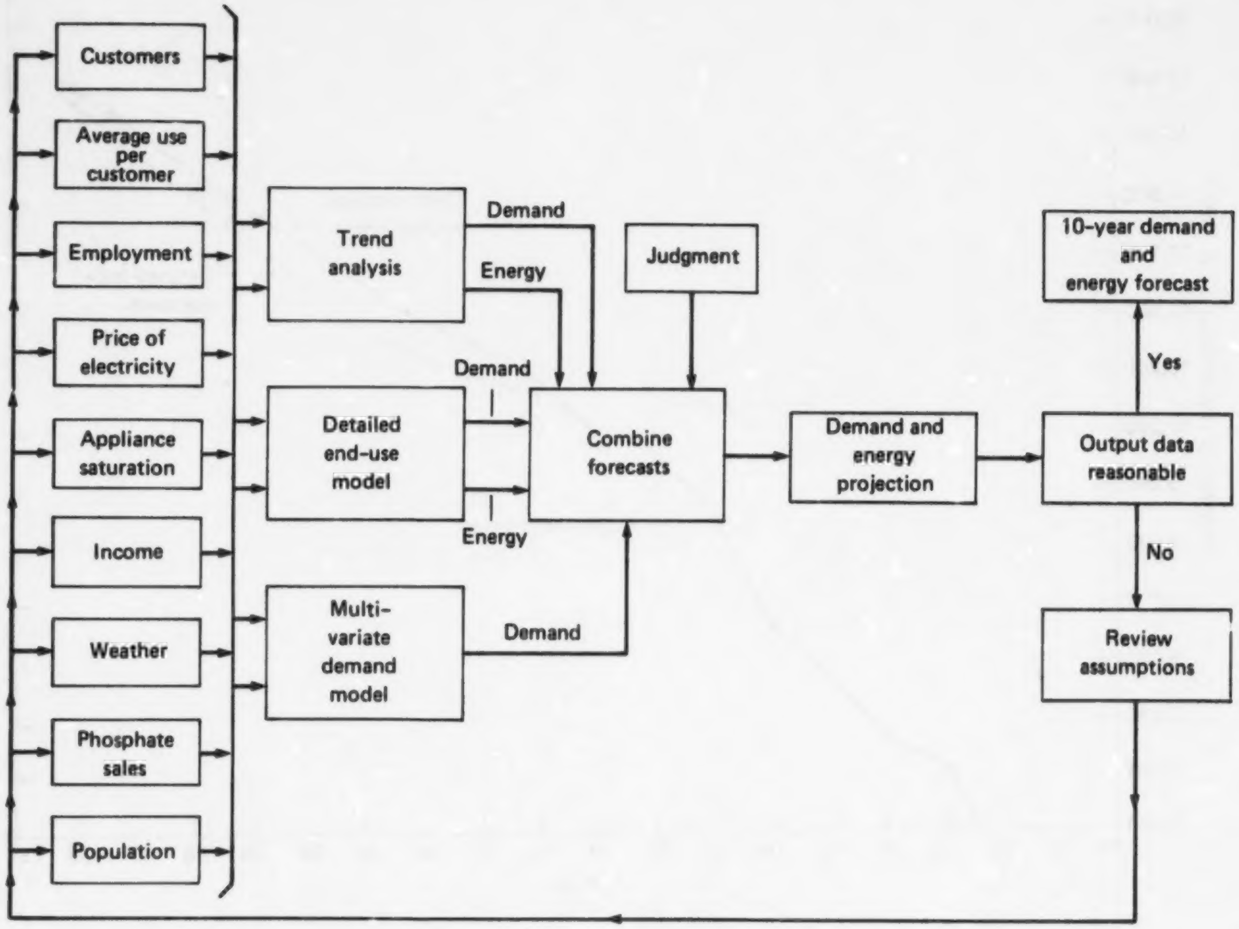
Figure 1-4. History and forecast of load and capacity additions for winter, Tampa Electric Company.



LOLP Loss of load probability.

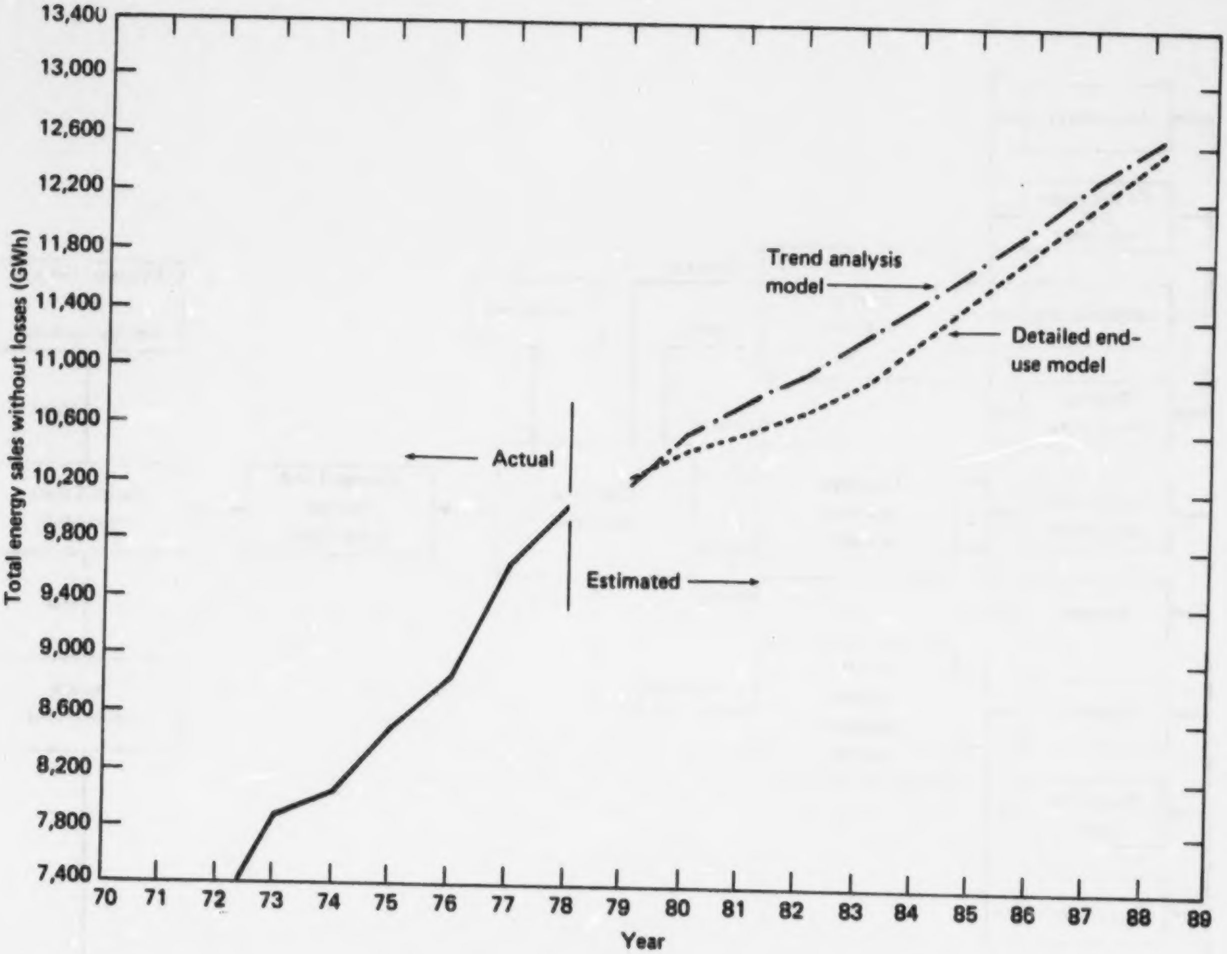
Source: System Planning Committee (1979).

Figure 1-5. Peninsular Florida baseload unit delay sensitivity.


Customers
Average use per customer
Employment
Price of electricity
Appliance saturation
Income
Weather
Phosphate sales
Population
Trend analysis
Detailed end-use model
Multi-variate demand model
Demand
Energy
Demand
Energy
Demand
Judgment
Combine forecasts
Demand and energy projection
Output data reasonable
Yes
No
10-year demand and energy forecast
Review assumptions

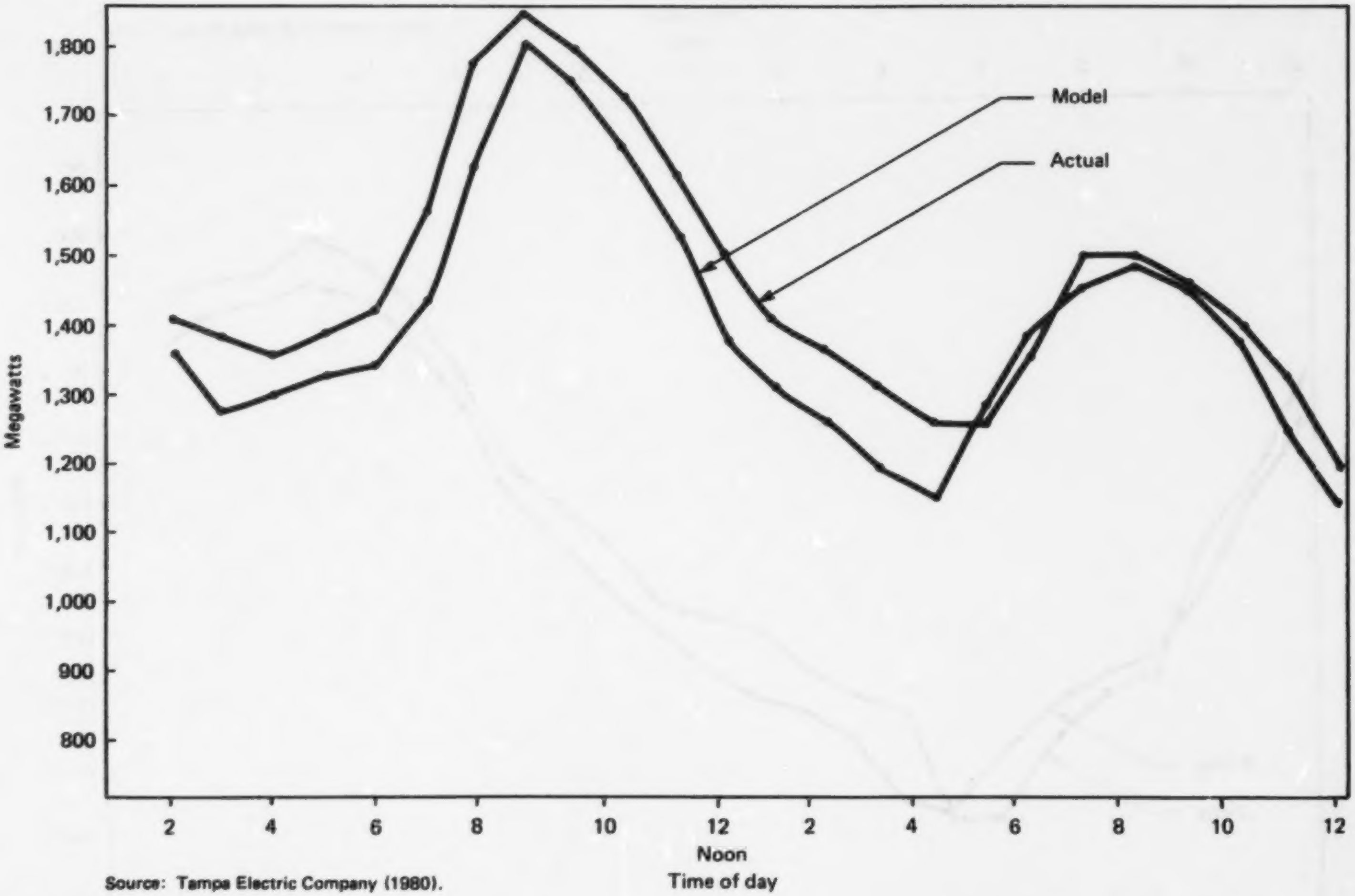
Source: Tampa Electric Company (1980).

Figure 1-6. Electricity demand forecasting technique employed by Tampa Electric Company.



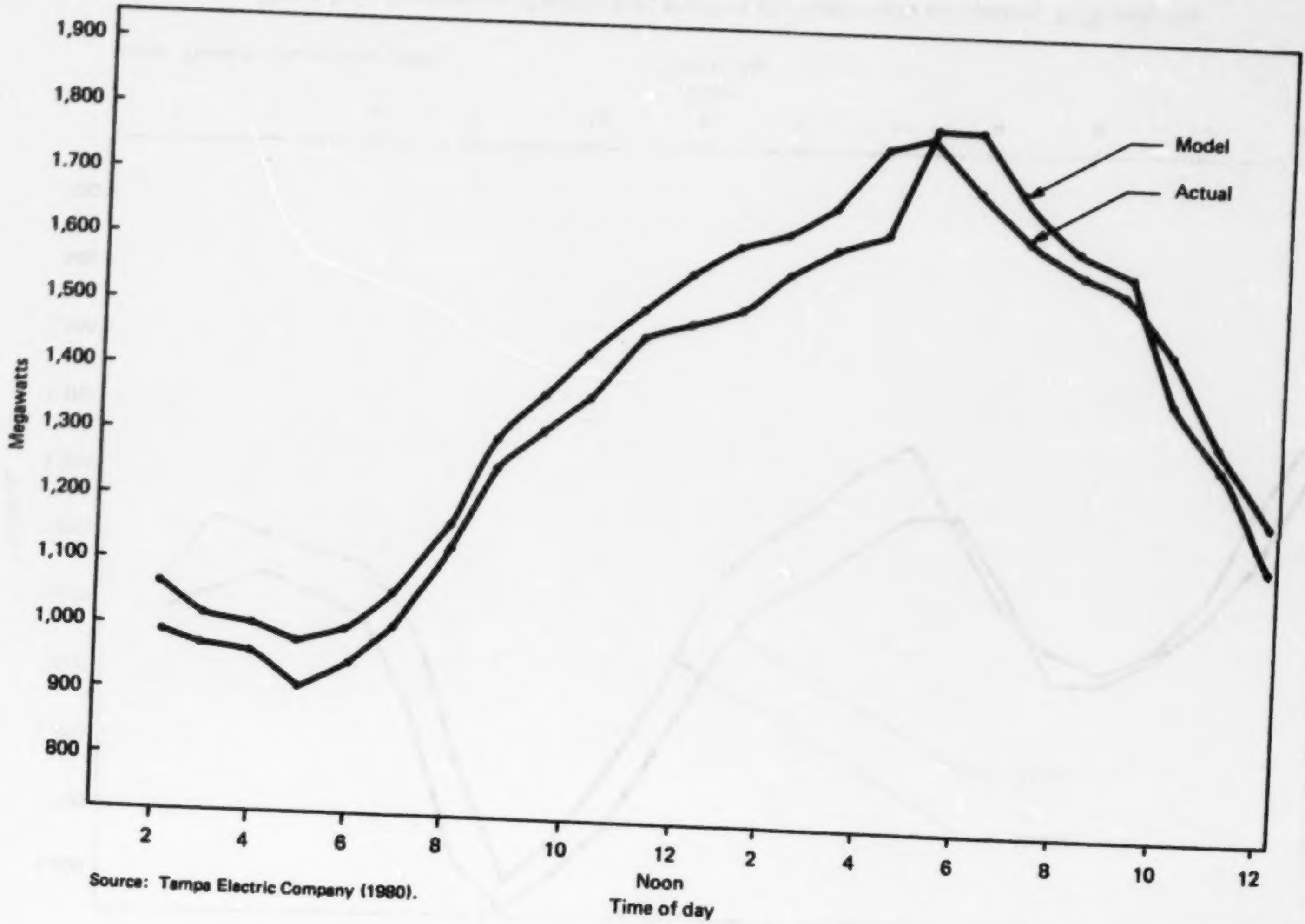
Source: Tampa Electric Company (1978).

Figure 1-7. Total energy sales by Tampa Electric Company for period 1970-1988.



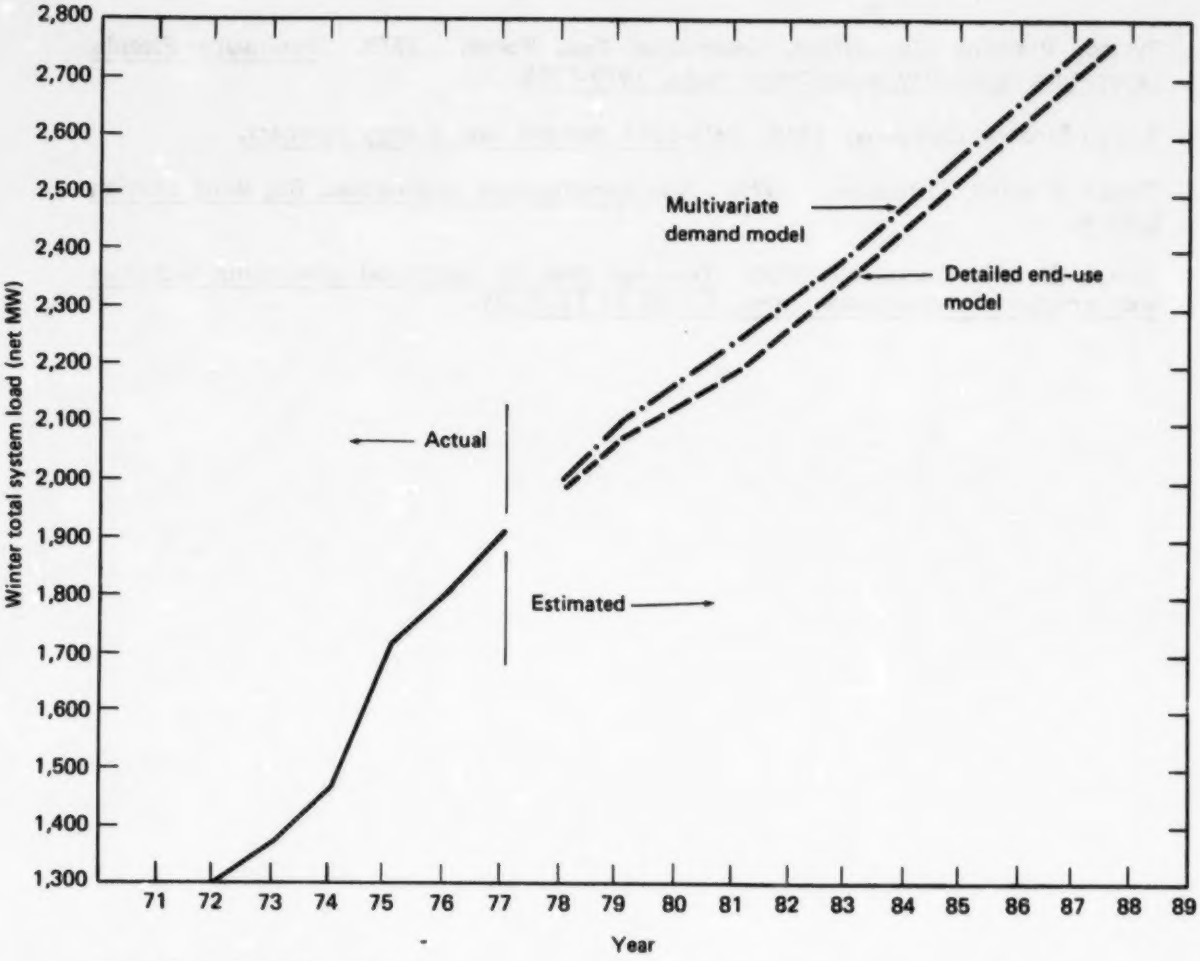
Source: Tampa Electric Company (1980).

Figure 1-8. Comparison of actual load profile and model results for January 1978 peak day, Tampa Electric Company.



Source: Tampa Electric Company (1980).

Figure 1-9. Comparison of actual load profile and model results for June 1978 peak day, Tampa Electric Company.



Source: Tampa Electric Company (1978).

Figure 1-10. Tampa Electric Company winter total system load for the period 1971-1988.

REFERENCES FOR CHAPTER 1

System Planning Committee, Generation Task Force. 1979. Peninsular Florida generation reliability assessment study, 1979-1988.

Tampa Electric Company. 1978. 1978-1988 demand and energy forecast.

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Tampa Electric Company. 1980. Ten-year plan for electrical generating facilities and associated transmission lines, 1-1-80 to 12-31-89.

Chapter 2

DESCRIPTION OF AREA OF INTEREST

2.1 THE ATMOSPHERE

2.1.1 CLIMATE

2.1.1.1 Regional Climatology

The climate of the site region is important for providing an overview of the environmental setting, although climatic factors are generally not directly used for impact analyses. The regional climate is discussed in terms of general temperature and precipitation characteristics, occurrence of various weather events, and indices of the potential for evaporation and wind erosion.

The site region is located within the Coastal Plains province of the Southern Plains and Lowlands Region climatic zone. In general, the flat terrain of the site region does not significantly affect meteorological conditions. Major influences on regional climate include latitude, general air mass, and storm movements, and proximity to moisture sources (Baldwin 1973).

The climate of the site region is considered subtropical and is frequently affected by warm maritime air masses throughout the year and occasionally by cold, dry polar air masses during winter. The modifying effects of the Atlantic Ocean, the Gulf of Mexico, and Tampa Bay contribute to the relatively mild and humid winters and the very warm and very humid summers. Occasionally, cold air masses reach the region during the winter, resulting in freeze conditions (Baldwin 1973).

The site region is located within the northeast trade winds zone (Baldwin 1973). Prevailing annual winds are from the east and are characterized by light to moderate average speeds (National Climatic Center 1979). However, wind directions are influenced locally by convectional forces inland and by land and sea breezes near the coast (Water Information Center 1974; Environmental Research and Technology, Inc. 1978). The region is located south of the major storm tracts that cross the United States (Naval Weather Service Command 1974; State University System of Florida Institute of Oceanography 1973). However, the region is subject to tropical storm activity and to frequent local convective thunderstorms (National Climatic Center 1979).

Meteorological conditions for the site can be characterized by data from the National Weather Service station at Tampa International Airport (Tampa) and from the observation station at MacDill Air Force Base. These are the climatological observation stations nearest to the site in the region. MacDill is located approximately 7 miles to the west-northwest of the site, and Tampa International Airport is located approximately 15 miles to the north-northwest (Figure 2-1). Both stations are adjacent to Tampa Bay, and meteorological conditions there can be considered representative of those at the site except for potential differences in wind directions associated with local sea and land breezes. These differences are due to differences in the orientation of the coastlines at each location.

Monthly and annual temperature and precipitation normals, and other climatological information, are presented in Tables 2-1 and 2-2 for Tampa and MacDill, respectively (National Climatic Center 1979; Environmental Technical Applications Center 1970). The data for the two stations are quite similar, as would be expected due to their proximity to each other. However, minor variations are apparent, in part due to differences in the data period. Approximately 60 percent of the annual precipitation occurs during June through September and is associated with frequent convective thunderstorms and occasional tropical storms. Snowfall is negligible and freezing temperatures are rare. The annual daily temperature ranges from near 60°F in January to near 82°F in August. Heavy fog (visibility of 0.25 mile or less) occurs during 24 days on an annual basis. Average annual relative humidity is 74 percent (National Climatic Center 1979). The region receives 66 percent of possible sunshine and the mean daily solar insolation is approximately 450 langleys (National Climatic Center 1979; Gale Research Company 1975).

Fugitive particulate emissions can be generated by wind erosion from disturbed soil surfaces. For this study, an empirical climatic factor C is used to indicate the wind erosion potential--a standard approach used by the U.S. Department of Agriculture (Skidmore and Woodruff, undated). This parameter includes a term to account for the cube of the average wind speed and also a term (Thornthwaite's precipitation-evaporation index) to account for surface moisture. Specifically, the climatic factor C can be calculated as follows (PEDCo 1973):

$$C = 34.5\left[V^3/(PE)^2\right] \qquad (2\text{-}1)$$

where

V = mean annual wind velocity (mph) corrected to a standard height of 35 feet

PE = yearly sum of 12 monthly precipitation-evaporation ratios times 10 (Huschke 1959)

The moisture content of surface materials is a more direct indicator of wind erosion potential than is the precipitation-evaporation index. However, moisture content measurements are not routinely made, whereas precipitation and evaporation measurements are frequently available. The annual PE value for the site region is approximately 95 inches and is indicative of a rainy climate (U.S. Environmental Protection Agency 1976).

Annual wind erosion climatic factors for the site region are less than 10, which is indicative of a very low erosion potential (Chepil, Siddoway, and Armbruster 1962; Jutze and Axetell 1976).

2.1.1.2 Severe Weather

Severe weather for the site region can be described in terms of maximum precipitation, tornadoes, extreme winds, and other weather events.

Probable maximum precipitation is a significant factor in evaluating peak runoff, the potential for flooding, severe erosion, and leaching. Estimates of maximum precipitation for the site region are presented in Table 2-3 (National Oceanic and Atmospheric Administration 1961).

Thunderstorms occur in the site region an average of 88 days annually. These storms occur mostly in the late afternoons of June, July, August, and September, and they are associated with convective activity (National Climatic Center 1979).

The frequency and intensity of tornadoes are important safety considerations for aboveground facilities. Dangers posed by tornadoes include windblown missiles, extreme pressure differentials, and extreme wind forces. A total of 42 tornadoes were reported within the 1-degree square in which the site is located during 1955-1967 (Pautz 1969). Generally, tornado path lengths in Florida have been short and damage has not been extensive. Tornadoes are most frequent during the spring, but they have occurred in all seasons and in conjunction with tropical storms. Occasionally waterspouts come inland, but they usually dissipate soon after reaching land (Water Information Center 1974).

Tropical storms frequently affect Florida. During the period 1885-1971, there were 160 tropical storms that significantly affected the State. Approximately 55 percent of these storms were of hurricane intensity (wind speeds of 73 mph or greater; Water Information Center 1974; Huschke 1959). In the 50-mile coastal strip from the northern border of Pinellas County to just below Tampa Bay, there is only a 10 percent chance of a tropical storm in any given year. The chance of hurricane-force winds in any year is 6 percent, and there is only a 1 percent chance of winds greater than 124 mph (Environmental Science and Engineering, Inc. 1976). The risk of a hurricane moving in from the Gulf of Mexico is greatest from June through October, and hurricanes occur with greatest frequency in September (State University System of Florida Institute of Oceanography 1973). These hurricanes are characterized by extremes of wind, precipitation, and tide, and they cause considerable damage, especially to coastal areas (National Climatic Center 1979).

Extreme wind, defined as the fastest passage of one mile of wind at 30 feet above ground, is an important factor for assessing wind loading on buildings and structures. Included in this category are all wind events except tornadoes. An extreme wind of 90 mph (American National Standards Institute 1972) for a recurrence interval of 50 years has been estimated based on the methodology developed by Thom (1954, 1967). Based on a gustiness factor of 1.3 (Huss 1946), the highest instantaneous gust expected once in 50 years at 30 feet above grade is 117 mph.

A total of 19 windstorms of 50 knots (57.6 mph) or greater and 9 occurrences of hail measuring 0.75 inch or more in diameter were reported in the 1-degree square in which the site is located during the period 1955-1967 (Pautz 1969). Freezing rain (glaze) generally does not occur in the site region (Baldwin 1973).

2.1.1.3 Atmospheric Dispersion Conditions

2.1.1.3.1 Restrictive Dispersion Conditions

Restrictive dispersion can be described in terms of mixing levels and also the persistence of poor dispersion conditions.

The term "mixing level" refers to the height above the surface below which relatively vigorous vertical mixing occurs. Therefore, the mixing level indicates the practical vertical limit of dispersion and is significant for dispersion over large distances and/or for cases involving significant plume rise. Mixing levels are generally estimated from the analysis of upper air temperature profiles obtained by balloon soundings. The "afternoon mixing level" is considered to be an appropriate indication of mixing-level conditions for the region. The afternoon mixing level is defined as the intersection of the vertical temperature profile at 1200 hours Greenwich mean time with the dry adiabatic extension of the maximum surface temperature observed from 1200 through 1600 hours local standard time (Holzworth 1972).

Seasonal and annual average afternoon mixing levels are presented in Table 2-4. Values are at a maximum during the spring and summer and at a minimum during the winter. Poor dispersion conditions that persist for long periods provide a potential for increased ground-level concentrations of emissions. The conditions of interest for this study are the occurrence of mixing heights of less than 1,500 meters on at least two consecutive days, wind speeds of less than 4.0 m/s, and no significant precipitation. These conditions are frequently associated with the stagnation of large-scale high-pressure systems.

The nearest weather station to the study area for which episode information is available is at Tampa International Airport. Here, a total of 23 episode-days associated with 9 episodes have been reported over a 5-year period (Holzworth 1972). These episodes occurred primarily during the winter season.

2.1.1.3.2 Topography

Since the region as well as the site can be characterized as flat terrain, significant topographic effects influencing dispersion meteorology are not expected.

2.1.1.3.3 Dispersion Conditions

The atmospheric transport and dispersion of emissions can be estimated on the basis of wind conditions and atmospheric stability. Wind and stability data summaries are available for Tampa and MacDill from the National Climatic Center (STAR summaries for selected periods). Summarized Tampa data for the periods 1960-1964, 1965-1969, and 1971-1975 are presented in this report, together with summarized MacDill data for the period 1965-1969. The 1971-1975 Tampa data have been considered as the primary data base. Tampa wind data are considered more representative, as discussed below, and the 1971-1975 period is the most recently summarized data set.

The atmospheric dilution of airborne emissions is directly proportional to wind speed for normal release conditions, all other factors remaining constant. Annual average wind speed summaries for Tampa and MacDill are presented in Table 2-5. Reported wind speeds are lower for Tampa for periods after 1964 than for the period 1960-1964 due to a change in the exposure heights in the anemometer. The annual wind speed reported at MacDill during the period 1965-1969 is lower than that reported at Tampa. This is attributed to the lower measurement height at MacDill and differences in the sensitivity of the wind sensors at the two stations.

Monthly average wind speeds at Tampa for the period 1971-1975 are presented in Table 2-6. The values compare well with the climatic normals that are presented in Table 2-1. Wind speeds are at a minimum from July through September and highest from February through May.

Annual wind roses for Tampa and MacDill are presented in Figure 2-2. The wind distributions for the different data sets summarized are quite similar. Annual prevailing winds are from the east. Monthly wind roses for Tampa (1971-1975) are presented in Figure 2-3. Winds from the east are quite frequent throughout the year. Westerly winds become significantly more frequent from March through August.

Atmospheric stability is a reliable indicator of the dispersion potential of the atmosphere; generally, stable conditions--as opposed to neutral or unstable conditions--decrease atmospheric dispersion. The generally accepted categories of atmospheric stability are presented in Table 2-7. These categories are based on Pasquill's classification method, which takes into account cloud cover, solar elevation (a function of the time of day, day of year, and location), and wind speed (Turner 1964).

Annual atmospheric stability summaries for Tampa and MacDill are presented in Table 2-8. Differences in the distributions can generally be attributed to differences in average wind speeds for each data set. Neutral ("D") stability is the most frequent individual stability category. Monthly stability summaries for Tampa (1971-1975) are presented in Table 2-9. Although neutral stability is the predominant individual category throughout the year, unstable conditions are relatively more frequent during the spring and summer.

2.1.2 AIR QUALITY

The Tampa Electric Company service area lies within the West-Central Florida Intrastate Air Quality Control Region (AQCR) (Citrus, Hardee, Hernando, Hillsborough, Levy, Manatee, Pasco, Polk, Pinellas, and Sumter Counties). The service area borders on the Southwest Florida Intrastate AQCR (Charlotte, Collier, DeSoto, Glades, Lee, Hendry, Highlands, and Sarasota Counties; 40 CFR 81.96; 36 FR 22,421, as amended by 44 FR 48,680).

Portions of these AQCRs have been designated as nonattainment areas for national ambient air quality standards (NAAQS; 40 CFR 81.310; 36 FR 22,421, as amended by 44 FR 48,680). An explanation of the various air quality standards and information on the location of nonattainment areas is presented in Section 5.1.2. A portion of Hillsborough County has been designated as nonattaining for suspended particulates, and a portion of Pinellas County has been designated as nonattaining for sulfur oxides. The whole of Hillsborough and Pinellas Counties has been designated as nonattaining for ozone. The remaining counties or portions of counties, for all criteria pollutants, either have been designated as better than national standards or cannot be classified.

Two portions of these AQCRs are classified as prevention of significant air quality deterioration (PSD) Class I areas, which are subject to the most stringent restraints on air quality deterioration. The closest Class I area is the Chassahowitzka National Wildlife Refuge, located approximately 92 kilometers north of the service area in Hernando County (40 CFR 51; 42 FR 57,159). The other PSD Class I area is the Everglades National Park, which is approximately 250 kilometers south of the service area. The remaining AQCRs are classified as PSD Class II areas and thus are subject to less stringent restraints on air quality deterioration.

Table 2-1. Climatological normals, means, and extremes for Tampa International Airport (National Climatic Center 1979)

Month	Temperatures °F							Normal Degree days Base 65 °F	
	Normal			Extremes					
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Heating	Cooling
(a)				32		32			
J	70.0	50.8	60.4	86	1975	23	1971	203	60
F	71.9	51.7	61.8	88	1971	24	1958	176	67
M	76.1	55.9	66.0	91	1949	34	1967	90	121
A	82.4	61.6	72.0	93	1975	40	1971	9	219
M	87.5	66.9	77.2	98	1975	49	1971	0	378
J	89.9	72.0	81.0	98	1977	61	1972	0	480
J	90.4	73.4	81.9	97	1964	63	1970	0	524
A	90.4	74.0	82.2	98	1975	67	1973	0	533
S	89.0	72.2	80.6	96	1972	59	1956	0	474
O	83.9	65.5	74.7	94	1959	40	1966	0	301
N	77.6	56.0	66.8	90	1971	23	1970	71	123
D	72.0	51.2	61.6	86	1978	18	1962	169	64
YR	81.7	62.6	72.2	98	JUN 1977	18	DEC 1962	718	3366

Month	Precipitation in inches										
	Water equivalent							Snow, Ice pellets			
	Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Maximum monthly	Year	Maximum in 24 hrs.	Year
(a)		32		32		32		32		32	
J	2.33	8.02	1948	T	1950	3.29	1953	0.2	1977	0.2	1977
F	2.86	7.95	1963	0.21	1950	3.25	1963	T	1951	T	1951
M	3.89	12.64	1959	0.06	1956	5.20	1960	0.0		0.0	
A	2.10	6.59	1957	T	1967	3.70	1951	0.0		0.0	
M	2.41	8.13	1970	0.17	1973	4.10	1976	0.0		0.0	
J	6.49	13.75	1974	1.86	1951	3.93	1974	0.0		0.0	
J	8.43	20.59	1960	2.31	1962	12.11	1960	0.0		0.0	
A	8.00	18.59	1949	2.35	1952	5.37	1949	0.0		0.0	
S	6.35	13.06	1947	1.20	1972	4.67	1950	0.0		0.0	
O	2.34	7.36	1952	0.23	1974	2.54	1968	0.0		0.0	
N	1.70	6.12	1963	T	1960	4.22	1963	0.0		0.0	
D	2.19	6.66	1950	0.21	1956	3.20	1969	0.0		0.0	
YR	49.38	20.59	JUL 1960	T	APR 1967	12.11	JUL 1960	0.2	JAN 1977	0.2	JAN 1977

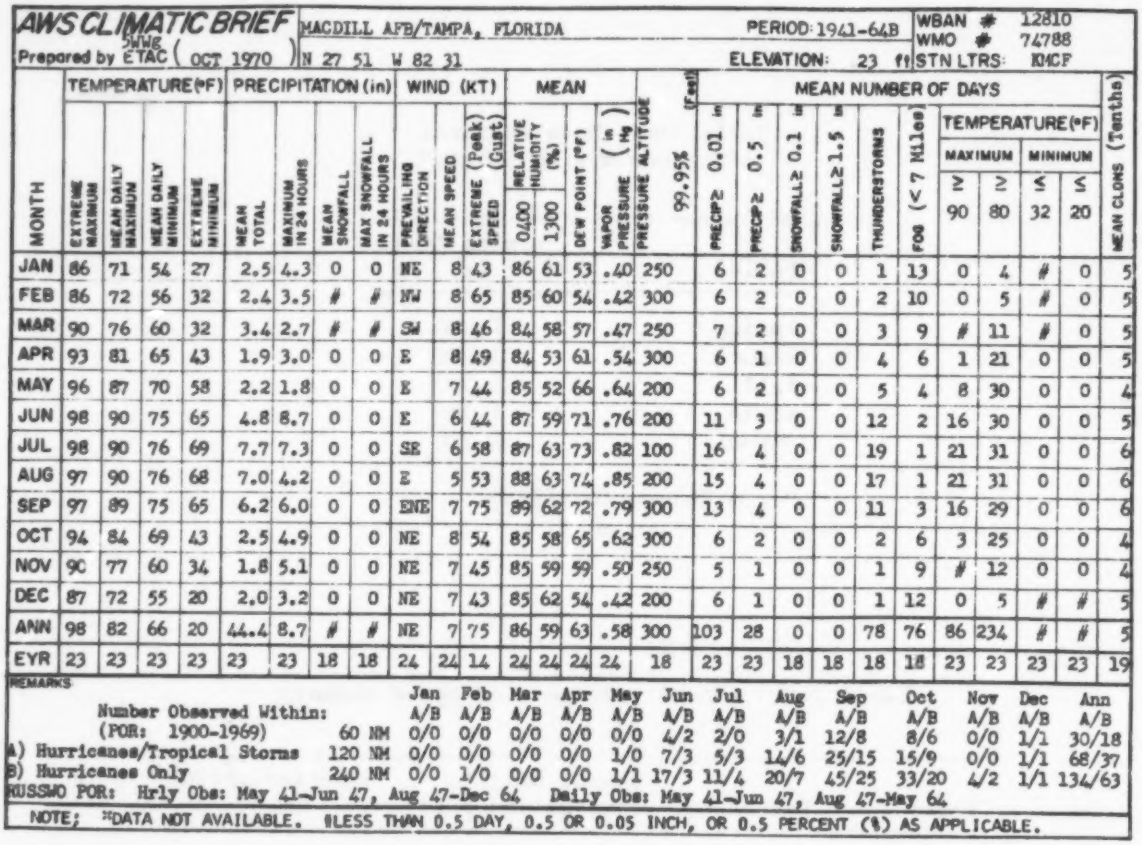
Month	Relative humidity pct.				Wind					Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days											Average station pressure mb.
	Hour 01	Hour 07	Hour 13	Hour 19	Mean speed m.p.h.	Prevailing direction	Fastest mile					Sunrise to sunset			Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	Temperatures °F				
	(Local time)						Speed m.p.h.	Direction	Year			Clear	Partly cloudy	Cloudy					Max. (b) 90° and above	Max. 32° and below	Min. 32° and below	Min. 0° and below	Elev. feet m.s.l.
(a)	13	13	13	13	32	14	26	26		32	32	32	32	32	32	32	32	32	19	19	19	19	6
J	86	86	59	73	8.9	N	35	29	1959	63	5.6	9	11	11	6	0	1	6	0	0	2	0	1020.0
F	81	84	55	68	9.5	E	50	32	1956	66	5.5	9	9	10	7	0	2	3	0	0	1	0	1019.6
M	81	85	54	66	9.8	S	43	29	1956	71	5.5	10	10	11	7	0	3	3	0	0	0	0	1018.0
A	81	86	49	60	9.6	ENE	37	29	1961	75	5.0	11	11	8	5	0	3	1	1	0	0	0	1018.2
M	81	85	51	61	9.1	E	46	36	1958	74	5.1	10	12	9	6	0	6	1	8	0	0	0	1015.4
J	83	85	59	67	8.3	E	67	31	1964	66	6.3	5	14	11	12	0	14	*	16	0	0	0	1016.3
J	84	86	62	72	7.3	E	58	32	1963	61	6.9	2	16	13	16	0	21	*	19	0	0	0	1017.7
A	86	90	63	76	7.3	ENE	38	11	1961	59	6.7	3	16	12	17	0	21	*	20	0	0	0	1017.4
S	85	89	61	76	8.1	ENE	56	34	1960	60	6.5	4	14	12	13	0	12	*	15	0	0	0	1015.4
O	84	87	56	71	9.0	NNE	38	02	1953	63	5.3	11	10	10	7	0	3	1	2	0	0	0	1018.0
N	84	87	55	73	8.7	NNE	40	29	1963	65	4.9	12	9	9	5	0	1	3	*	0	*	0	1019.8
D	84	84	58	74	8.8	N	43	36	1953	62	5.5	10	10	11	7	0	1	5	0	0	1	0	1019.5
YR	83	86	57	69	8.7	E	67	31	JUN 1964	66	5.7	96	142	127	107	0	88	24	82	0	4	0	1017.8

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Fastest mile wind 84 in September 1935.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

Table 2-2. Climatological normals, means, and extremes for MacDill Air Force Base (Environmental Technical Applications Center 1970)



AWS CLIMATIC BRIEF
Prepared by 5WWg ETAC (OCT 1970)
MACDILL AFB/TAMPA, FLORIDA
N 27 51 W 82 31
PERIOD: 1941-64B
ELEVATION: 23 ft
WBAN # 12810
WMO # 74788
STN LTRS: KMCF

MONTH	TEMPERATURE (°F)				PRECIPITATION (in)				WIND (KT)			MEAN				PRESSURE ALTITUDE 99.95% (Feet)	MEAN NUMBER OF DAYS										MEAN CLDNS (Tenths)
	EXTREME MAXIMUM	MEAN DAILY MAXIMUM	MEAN DAILY MINIMUM	EXTREME MINIMUM	MEAN TOTAL	MAXIMUM IN 24 HOURS	MEAN SNOWFALL	MAX SNOWFALL IN 24 HOURS	PREVAILING DIRECTION	MEAN SPEED	EXTREME (Peak) (Gust) SPEED	RELATIVE HUMIDITY (%)		DEW POINT (°F)	VAPOR PRESSURE (in Hg)		PRECIP≥ 0.01 in	PRECIP≥ 0.5 in	SNOWFALL≥ 0.1 in	SNOWFALL≥ 1.5 in	THUNDERSTORMS	FOG (< 7 Miles)	TEMPERATURE (°F) MAXIMUM		TEMPERATURE (°F) MINIMUM		
												0400	1300										≥ 90	≥ 80	≤ 32	≤ 20	
JAN	86	71	54	27	2.5	4.3	0	0	NE	8	43	86	61	53	.40	250	6	2	0	0	1	13	0	4	#	0	5
FEB	86	72	56	32	2.4	3.5	#	#	NW	8	65	85	60	54	.42	300	6	2	0	0	2	10	0	5	#	0	5
MAR	90	76	60	32	3.4	2.7	#	#	SW	8	46	84	58	57	.47	250	7	2	0	0	3	9	#	11	#	0	5
APR	93	81	65	43	1.9	3.0	0	0	E	8	49	84	53	61	.54	300	6	1	0	0	4	6	1	21	0	0	5
MAY	96	87	70	58	2.2	1.8	0	0	E	7	44	85	52	66	.64	200	6	2	0	0	5	4	8	30	0	0	4
JUN	98	90	75	65	4.8	8.7	0	0	E	6	44	87	59	71	.76	200	11	3	0	0	12	2	16	30	0	0	5
JUL	98	90	76	69	7.7	7.3	0	0	SE	6	58	87	63	73	.82	100	16	4	0	0	19	1	21	31	0	0	6
AUG	97	90	76	68	7.0	4.2	0	0	E	5	53	88	63	74	.85	200	15	4	0	0	17	1	21	31	0	0	6
SEP	97	89	75	65	6.2	6.0	0	0	ENE	7	75	89	62	72	.79	300	13	4	0	0	11	3	16	29	0	0	6
OCT	94	84	69	43	2.5	4.9	0	0	NE	8	54	85	58	65	.62	300	6	2	0	0	2	6	3	25	0	0	4
NOV	90	77	60	34	1.8	5.1	0	0	NE	7	45	85	59	59	.50	250	5	1	0	0	1	9	#	12	0	0	4
DEC	87	72	55	20	2.0	3.2	0	0	NE	7	43	85	62	54	.42	200	6	1	0	0	1	12	0	5	#	#	5
ANN	98	82	66	20	44.4	8.7	#	#	NE	7	75	86	59	63	.58	300	103	28	0	0	78	76	86	234	#	#	5
EYR	23	23	23	23	23	23	18	18	24	24	14	24	24	24	24	18	23	23	18	18	18	18	23	23	23	23	19

REMARKS

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Number Observed Within:		A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
(POR: 1900-1969)	60 NM	0/0	0/0	0/0	0/0	0/0	4/2	2/0	3/1	12/8	8/6	0/0	1/1	30/18
A) Hurricanes/Tropical Storms	120 NM	0/0	0/0	0/0	0/0	1/0	7/3	5/3	14/6	25/15	15/9	0/0	1/1	68/37
B) Hurricanes Only	240 NM	0/0	1/0	0/0	0/0	1/1	17/3	11/4	20/7	45/25	33/20	4/2	1/1	134/63

RUSSWO POR: Hrly Obs: May 41-Jun 47, Aug 47-Dec 64 Daily Obs: May 41-Jun 47, Aug 47-May 64

NOTE; *DATA NOT AVAILABLE. #LESS THAN 0.5 DAY, 0.5 OR 0.05 INCH, OR 0.5 PERCENT (%) AS APPLICABLE.

Table 2-3. Rainfall in inches for 0.5-, 1-, 6-, 12-, and 24-hour rainfall at 1- to 50-year frequencies[a]

Frequency in years	30-min rainfall	1-hour rainfall	6-hour rainfall	12-hour rainfall	24-hour rainfall
1	1.6	2.1	3.2	3.7	4.2
2	1.8	2.2	3.7	4.5	5.2
5	2.2	3.0	5.0	5.8	7.0
10	2.5	3.3	5.7	6.9	8.1
25	2.9	3.6	6.5	8.1	9.5
50	3.1	4.0	7.5	9.0	10.5

[a]From National Oceanic and Atmospheric Administration (1961).

Table 2-4. Mean regional afternoon mixing levels[a]

Period	Mixing level (m)
Spring	1,400
Summer	1,400
Fall	1,300
Winter	1,100
Annual	1,300

[a]From Holzworth (1972).

Table 2-5. Annual average wind speed summary

Speed	Period	Sensor height above ground (ft)	Average speed (mph)
Tampa	1960-1964	56	10.9
Tampa	1965-1969	22	8.4
MacDill	1965-1969	13	7.1
Tampa	1971-1975	22	8.5

Table 2-6. Monthly average wind speeds for Tampa International Airport (1971-1975)

Month	Wind speed (mph)
January	8.1
February	9.4
March	9.7
April	9.8
May	9.1
June	8.6
July	7.7
August	7.0
September	7.6
October	8.6
November	8.4
December	8.4

Table 2-7. Atmospheric stability categories

Stability category	General category	Turbulence type
A = very unstable B = moderately unstable C = slightly unstable	Unstable	High atmospheric turbulence
D = neutral	Neutral	Moderate atmospheric turbulence
E = slightly stable F = moderately stable G = very stable	Stable	Low atmospheric turbulence

Table 2-8. Annual atmospheric stability summary (%)

Station	Period	A	B	C	D	E	F	G
Tampa	1960-1964	0.35	3.96	12.73	51.26	19.98	10.50	1.21
Tampa	1965-1969	0.31	7.04	14.76	37.42	--	40.47	--
MacDill	1965-1969	2.59	10.41	14.65	29.83	--	42.52	--
Tampa	1971-1975	0.18	6.14	15.25	37.75	17.55	17.77	5.34

Abbreviations:

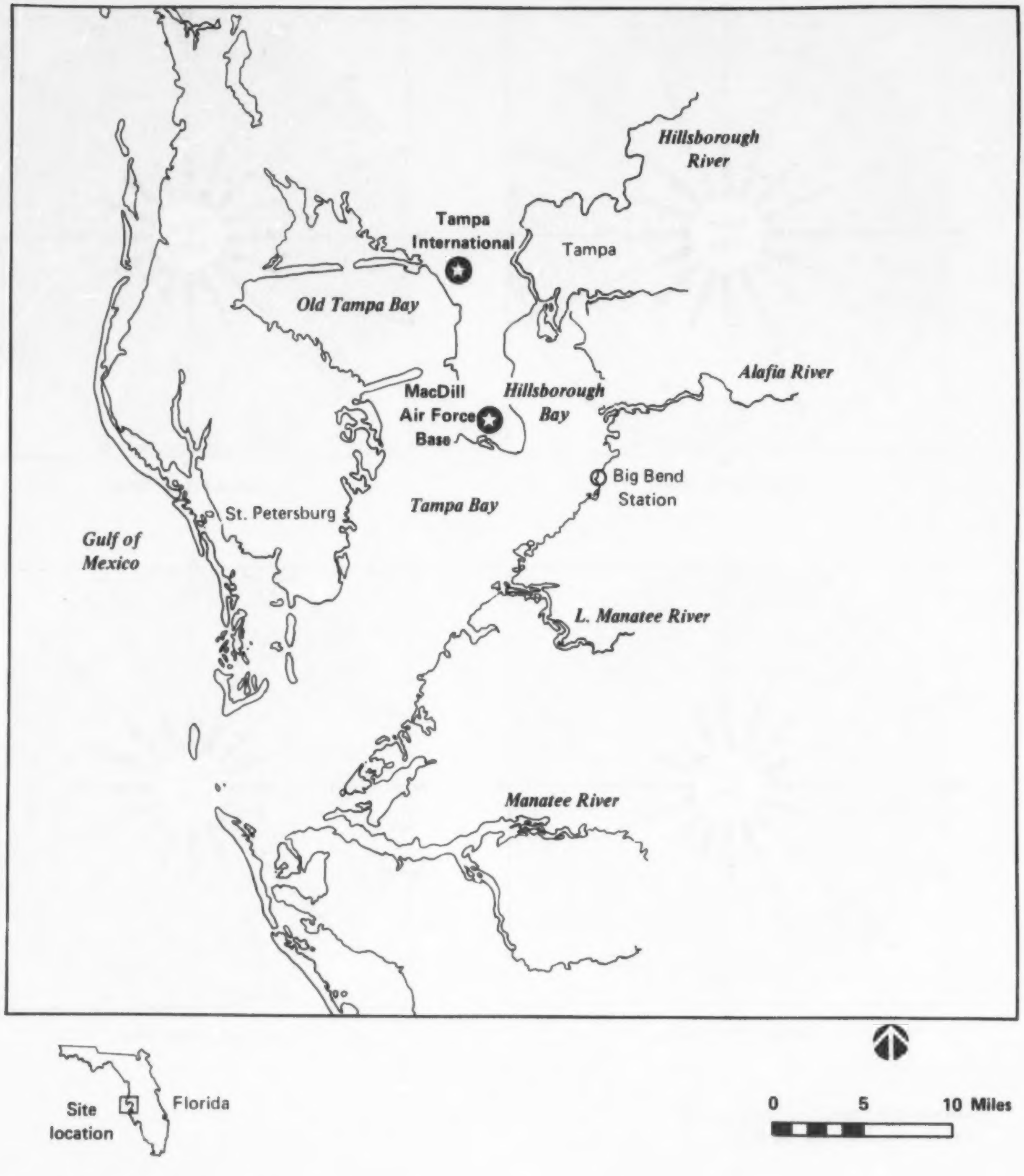
A = very unstable.
B = moderately unstable.
C = slightly unstable.
D = neutral.
E = slightly stable.
F = moderately stable.
G = very stable.

Table 2-9. Monthly atmospheric stability summaries (%) for Tampa International Airport (1971-1975)

Month	A	B	C	D	E	F	G
January	0.00	2.66	12.66	46.13	14.52	17.98	6.05
February	0.00	3.13	9.55	49.73	17.59	14.55	5.45
March	0.00	2.58	13.47	44.68	16.77	16.37	6.13
April	0.17	5.00	14.17	41.00	18.92	14.58	6.17
May	0.08	6.94	20.32	37.50	16.45	13.95	4.76
June	0.17	10.75	21.50	34.75	15.50	13.42	3.92
July	0.56	10.65	20.32	40.73	17.74	15.24	4.76
August	0.56	13.31	15.89	35.73	20.40	19.84	4.27
September	0.58	8.33	13.67	28.59	21.33	23.42	4.08
October	0.08	5.32	13.06	32.50	18.23	23.63	6.37
November	0.00	2.83	14.83	37.75	18.17	21.75	4.67
December	0.00	2.02	13.15	44.03	15.16	18.31	7.34

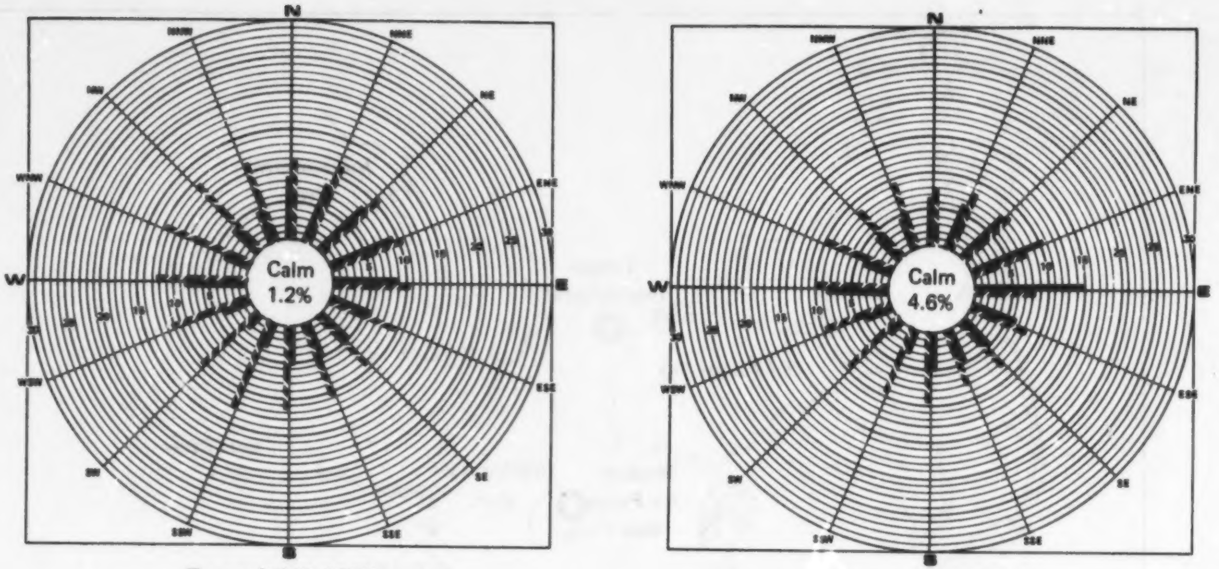
Abbreviations:

A = very unstable.
B = moderately unstable.
C = slightly unstable.
D = neutral.
E = slightly stable.
F = moderately stable.
G = very stable.


Hillsborough River
Tampa International
Tampa
Old Tampa Bay
MacDill Air Force Base
Hillsborough Bay
Alafia River
Big Bend Station
St. Petersburg
Tampa Bay
Gulf of Mexico
L. Manatee River
Manatee River
Site location
Florida
0
5
10 Miles

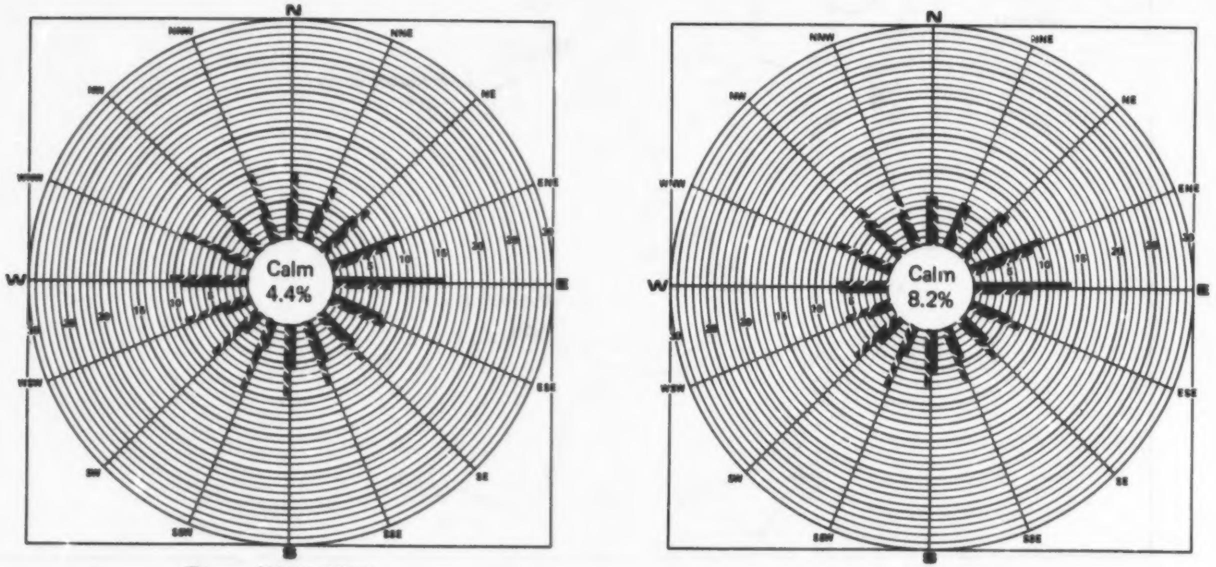
Source: Tampa Electric Company (1975).

Figure 2-1. Regional meteorological stations.



Tampa (1960-1964)

Tampa (1965-1969)

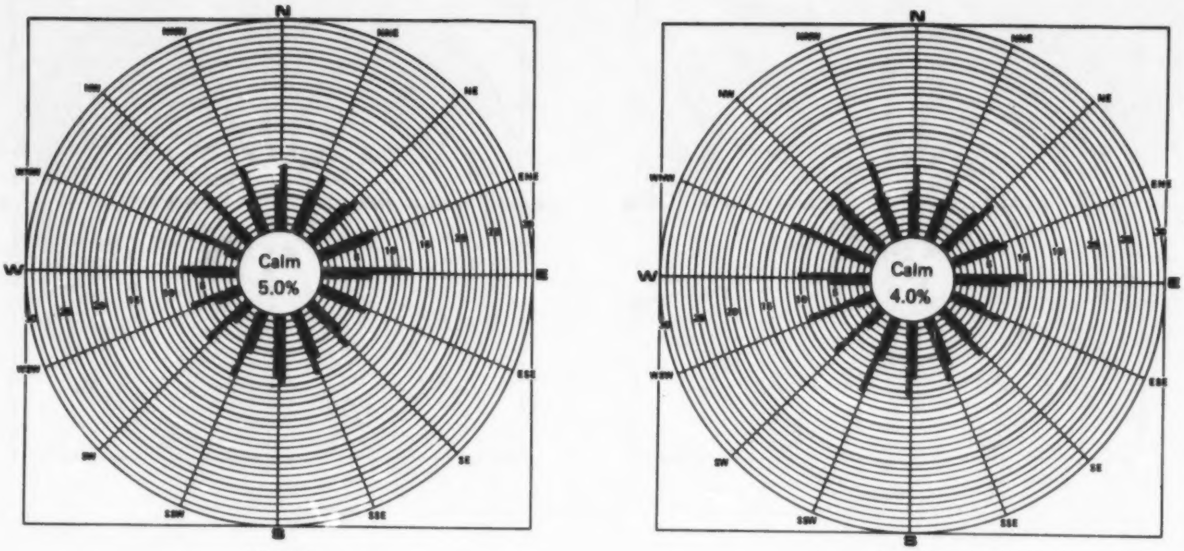


Tampa (1971-1975)

MacDill (1965-1969)

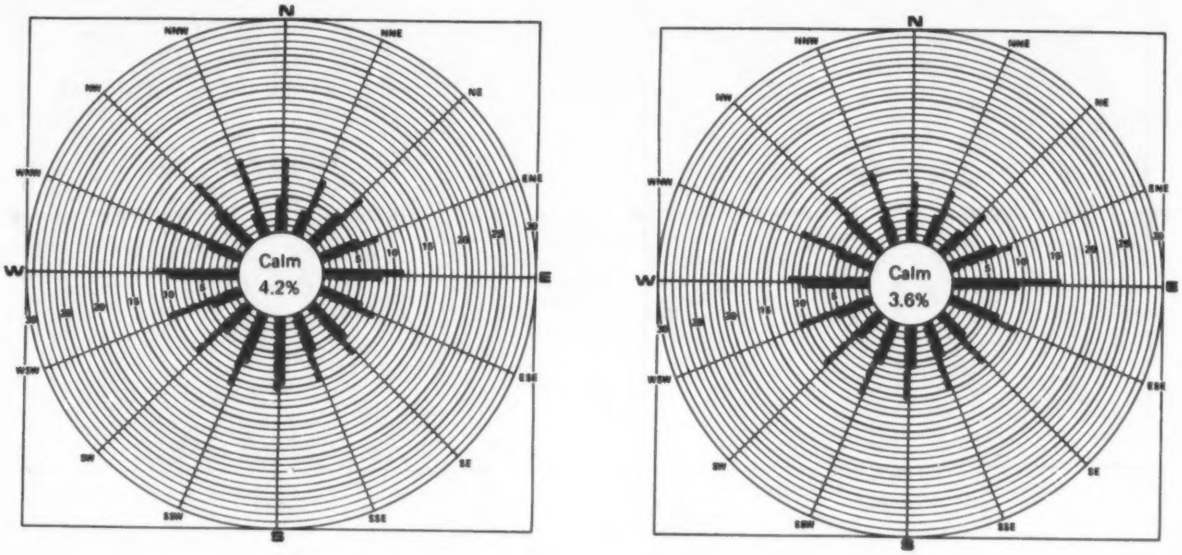
━━━ Wind direction frequency (%)
╍╍╍ Mean wind speed (mph)

Figure 2-2. Annual wind roses for Tampa and MacDill.



January

February



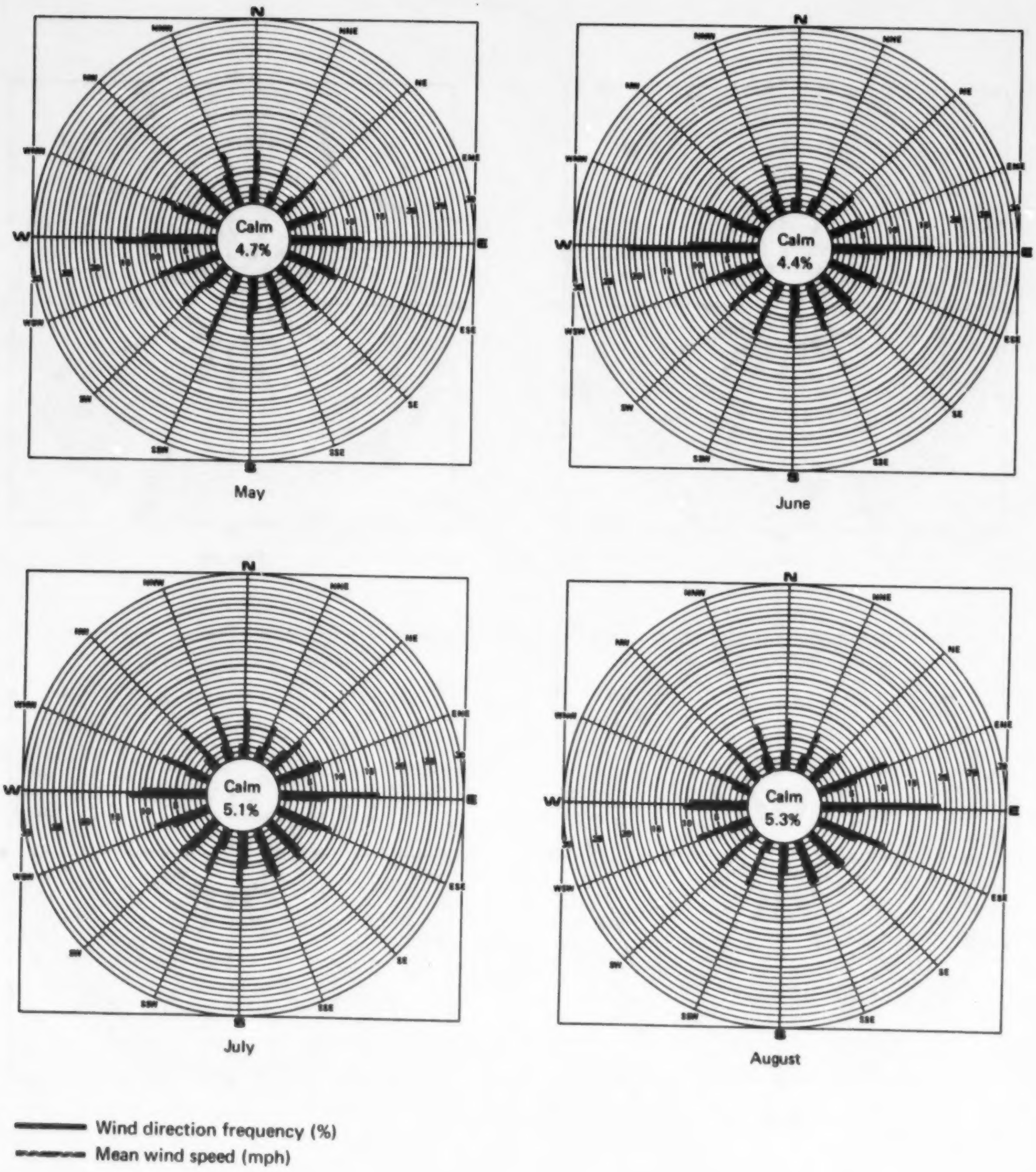
March

April

▬ Wind direction frequency (%)

▬ Mean wind speed (mph)

Figure 2-3. Monthly wind roses for Tampa for the period 1971-1975 (Sheet 1 of 3).

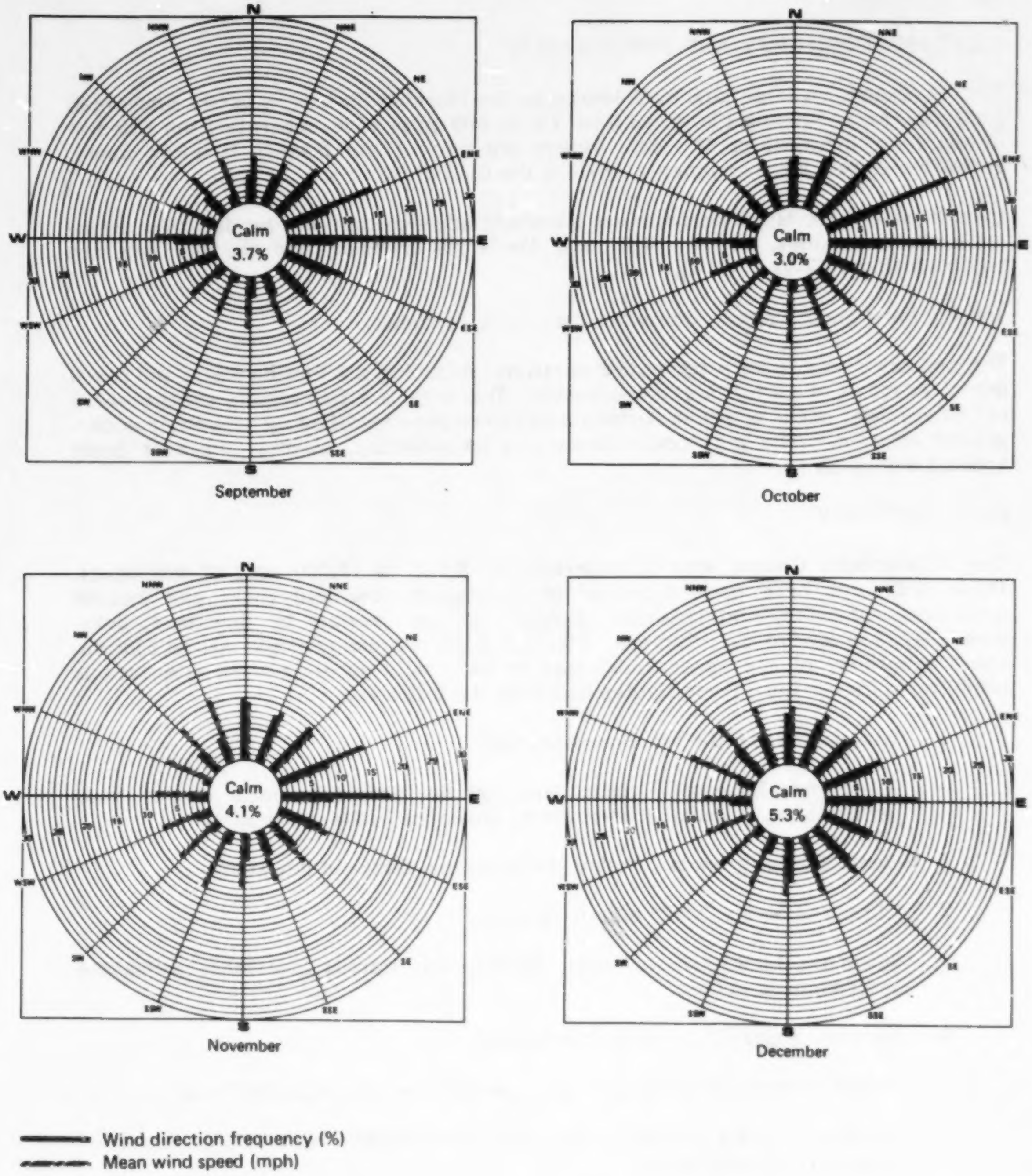

May

June

July

August

Figure 2-3. Monthly wind roses for Tampa for the period 1971-1975 (Sheet 2 of 3).



September

October

November

December

Figure 2-3. Monthly wind roses for Tampa for the period 1971-1975 (Sheet 3 of 3).

2.2 THE LAND

2.2.1 PHYSIOGRAPHY AND TOPOGRAPHY

Florida occupies a large land mass known as the Floridan Plateau, a partly submerged platform nearly 500 miles long and from 250 to 400 miles wide, separating the Atlantic Ocean from the Gulf of Mexico. Nearly one-half of the Plateau is under water, giving the state a large continental shelf in the Gulf of Mexico.

Five physiographic landform areas are generally acknowledged in Florida: the coastal lowlands, everglades, central highlands, Marianna lowlands, and the northwestern highlands (Figure 2-4).

The Big Bend Station site is located in the coastal lowlands.

The coastal lowlands form the entire coastline, including the Florida Keys, and reach inland as much as 60 miles at some points. This area is a flat region, except where old dune ridges occur or where surface areas have been modified by erosion or underground solution. The gulf coast appears to be subsiding, whereas the east coast appears emergent.

2.2.2 GEOLOGY

The Hillsborough County area is underlain by 8,000 to 13,000 feet of sediments. These sediments have been deposited on crystalline basement rocks and include sandstone, anhydrite, and dolomite of Mesozoic age overlain by limestone, dolomite, clay, and sand of Cenozoic age. Figure 2-5 is a regional geologic map of Florida. The stratigraphy of the upper 1,000 feet of rock units underlying the site area is exhibited in Figure 2-6. These figures illustrate the following:

1. Eocene Series (60-40 million years old)

   Avon Park Limestone--crystalline, lignitic, porous dolomite in the lower part; chalky, granular, foraminiferal limestone in the upper part.

   Ocala Group--granular, chalky, fossiliferous coquinoid limestone.

2. Oligocene Series (40-25 million years old)

   Suwannee Limestone--granular, porous, fossiliferous limestone; crystalline and dolomitic in part.

3. Miocene Series (25-11 million years old)

   Tampa Formation--sandy, porous to dense limestone; silicified in part.

   Hawthorn Formation--clay and marl interbedded with sandy limestone, sand, silt, and shell beds.

4. Late Miocene and Pliocene Series (11-1 million years old)

   Sand and gravel with phosphate, shells, clay, and lignite.

5. Pleistocene Series (less than 1 million years old)

Older terrace deposits--sand, silt, and some clay.

Pamlico Sand--sand with shells, calcareous clays, and occasional limestone.

The rocks of Cenozoic age in this area were deposited in horizontal strata. During deposition, however, the land subsided toward the southwest, resulting in a thickening of sediments in that direction.

The formation of the Floridan Plateau (peninsula) is attributed to the development of a long, gentle arch with its axis oriented nearly parallel to the peninsula. Near the end of Oligocene time, the Ocala uplift was developed. While the mechanism behind the formation of this structure is not known for sure, it has been suggested that it was produced by compressive crustal stresses. The uplift resulted in a broad, elongate dome that trends southeast. The Oligocene and Miocene formations were developed on the flanks of this growing dome, resulting in the thickening mentioned above.

Longitudinal tension fractures, oriented parallel to the peninsular axis, are common in the Cenozoic rocks of this region. These fractures developed as stress relief features in response to the forces which provided the Ocala uplift. Typically, these fractures are minor structures; however, occasional displacements of up to 200 feet have been noted.

The remnants of four shorelines and five marine terraces of Pleistocene age have been identified in the area surrounding the site. The rise and fall of the sea which produced these terraces is attributed to the advance and retreat of the Pleistocene continental glaciers hundreds of miles to the north (with sea level rising during interglacial periods and falling during glacial periods). These shoreline features and marine plains developed during periods of relative stability. The shorelines are now marked by topographic escarpments. The five terraces and the altitudes of their shorelines are listed below.

1. Sunderland--170 feet
2. Wicomico--100 feet
3. Penholoway--70 feet
4. Talbot--42 feet
5. Pamlico--25 feet

The contacts and internal stratification of these Pleistocene terraces are essentially horizontal and undisturbed.

2.2.3 SOILS

The State of Florida contains four soil orders: (1) spodosols, (2) entisols, (3) histosols, and (4) ultisols (Figure 2-7). Spodosols not only typify the Tampa Bay region, but comprise approximately half of the state. Originally developed from sandy parent material of marine origin, spodosols can support vegetable and cattle production. The second most widely distributed soil order in Florida is entisols. In the north-central part of the state, entisols have a sandy or loamy sand texture and are typically dry, whereas entisols of the peninsula's lower tip are seasonally saturated. Florida and Minnesota are two states having large areas of histosols (Foth and Turk 1958). Histosols are organic and develop where the soil is saturated at least one month each year. Ultisols of the upper panhandle represent the oldest and most weathered soil order. They have low organic content and support diverse indigenous vegetation as well as agriculture.

Many of the soils in west-central Florida were derived from sandy formations deposited at various intervals during the Pleistocene Epoch (Texas Instruments, Inc. 1978a). Typical parent materials were limestones, marls, and noncalcareous deposits of mixed sand, silt, and clay. Alluvial deposits along larger streams and organic deposits in wet areas also contributed to the parent materials.

2.2.4 TERRESTRIAL FLORA AND FAUNA

2.2.4.1 Physiography

The TECO site is located on the eastern shore of Tampa Bay in Hillsborough County, Florida, in the Floridian section of the Coastal Plain physiographic province (Fenneman 1938). Because of its geographical position, physical shape, and geologic history, peninsular Florida has played an important role in the evolution and dispersion of the flora and fauna of the southeastern Coastal Plain (Woodruff 1973). Various aspects of plant and animal distribution throughout this region are discussed in relation to past geologic and climatic events by Neill (1957).

Cooke (1945) includes the western and southeastern parts of Hillsborough County in the coastal lowlands topographic division and the eastern part of the county in the central highlands. The topography of Hillsborough County ranges predominantly from flat to gently rolling. Minor differences in elevation and soil drainage often influence the distribution of plants, which in turn influences the fauna of local areas (West and Arnold 1956; Texas Instruments, Inc. 1978a). The county was once covered with dense forests composed mainly of pine, some hardwood, and cypress trees. Virtually all of the original forests have been cut (Leighty 1958). In large part, the well-drained to somewhat poorly drained soils have been cleared for agriculture and are used primarily for growing winter vegetables and citrus fruits, and for raising livestock. Nonagricultural land includes forest, range, building sites, and recreational areas such as the Hillsborough River State Park. Major land use categories for Hillsborough County in 1967 were forestland, 43 percent; cropland, 15 percent; pastureland and rangeland, 22 percent; urban and built-up areas, 10 percent; and Federal noncropland, small water areas, and other land, 10 percent (U.S. Department of Agriculture, undated).

The southern half of Hillsborough County is drained primarily by the Alafia and Little Manatee rivers. Other areas near Tampa Bay are drained by coastal basins. The Alafia River is 24 miles long and the Little Manatee is 39 miles long. Major springs occurring in Hillsborough County are the Buckhorn, Eureka, Lithia, Purity, and Sulphur. Most of these are located near the coast. Both the county and the region have been extensively drained for construction and agriculture.

2.2.4.2 Flora

The vegetation of Hillsborough County has been characterized according to four major land-use categories: agricultural land, rangeland, forestland, and wetlands (Texas Instruments Inc. 1978a).

2.2.4.2.1 Agricultural Land

Agricultural land in Hillsborough County is composed primarily of cropland and pasture. Principal crops include tomatoes, watermelons, cucumbers, green peppers, and strawberries. Fruit and nut crops are also produced. Pasturelands are commonly seeded with introduced and native grasses such as crabgrass (Digitaria spp.), paspalum (Paspalum spp.), and Bermuda grass (Cynodon dactylon). Old fields resulting from recently abandoned or idle croplands are also common throughout the county. Species composition of these ruderal communities varies considerably; however, the pattern of succession is generally the same during the first few years. Following the first year of abandonment, vegetation is composed predominantly of annuals; after 2 or more years of undisturbed growth, perennial and biennial herbaceous species predominate; young pines are generally evident by the fourth year. Common herbaceous plants of old fields are listed in Table 2-10.

2.2.4.2.2 Rangeland

Rangeland is land with potential (or actual) natural vegetation that would be (or is) composed principally of native grasses, forbs, and shrubs valuable as forage (U.S. Department of Agriculture, undated). Three categories of rangeland occur in Hillsborough County: herbaceous, shrub and brush, and a mix of the two (Texas Instruments, Inc. 1978a).

Herbaceous rangelands are dominated by naturally occurring grasses, the most abundant of which are the wiregrasses (Aristida spp.). When present, shrubs are usually low, with saw palmetto (Serenoa repens) being the most common species; pine trees, if present, are scattered. Herbaceous rangelands are commonly referred to as dry prairie or palmetto prairie. Fire is important in maintaining the general character and productivity of these areas.

For the most part, shrub and brush rangelands are former croplands, pastures, or herbaceous rangelands that have become overgrown in shrub species; wax myrtle (Myrica cerifera) is the most common of these shrub species. Mixed rangeland includes more than a one-third mixture of either herbaceous or shrub and brush rangeland. The species composition is similar to that of other rangeland categories.

2.2.4.2.3 Forestland

Forestland includes wooded areas that have a canopy closure of 10 percent or more and are stocked with trees capable of producing timber or other wood products. Upland forests in Hillsborough County are classified as evergreen, deciduous, or mixed forest. (Wetland forest types in the county are described in Subsection 2.2.4.2.4.)

Evergreen forests are largely composed of trees that remain green throughout the year. In most cases, coniferous evergreens (softwoods) predominate. Evergreen forests in Florida are called pine flatwoods. They occur on level areas of poorly drained sands and represent the most common vegetation type in Florida. The only common tree in the typical flatwoods forest is the longleaf pine (Pinus palustris). Slash pine (Pinus elliottii) may also be present but is generally restricted to wetter sites. The trees may be scattered or may occur in dense stands. The open canopy permits considerable light to penetrate and a heavy shrub and ground cover to develop. The shrub layer is characterized by saw palmetto, several species of holly (Ilex spp.), scrub oaks (Quercus spp.), and a variety of heaths (Ericaceae). Wiregrasses (Aristida spp.) are typically the most abundant herbaceous species. Garren (1943) concluded that fire is responsible for the perpetuation and maintenance of the typical flatwoods forest composition. Both longleaf pine and slash pine flatwoods give way to hardwoods when fire is eliminated.

Deciduous forests (usually referred to as hardwoods) typically lose their leaves at the end of the frost-free season (March through December) or at the beginning of a dry season (Anderson et al. 1976; Texas Instruments, Inc. 1978a). This forest category is separated into three kinds of hammock*: cabbage palm, live oak, and mesic. The cabbage palm hammock is found on low-lying, poorly drained soils and is generally characterized by dense stands of cabbage palm (Sabal palmetto). Water oak (Quercus nigra) and sweetgum (Liquidambar styraciflua) are often important codominants; however, these species are not fire-resistant and dominance by cabbage palm is favored by fire. A xeric hammock type dominated by live oak (Quercus virginiana) is found on well-drained soils. The canopy is typically open, the shrub layer is low, and the herbaceous vegetation is sparse. Mesic hammocks occupy areas of intermediate soil moisture. Dominant tree species include the southern magnolia (Magnolia grandiflora) and the American holly (Ilex opaca). Characteristic plants of the hammock communities are listed in Tables 2-11 through 2-13.

Mixed forestland includes all forested areas that contain more than a one-third mixture of evergreen or deciduous species. Two mixed forest types, dominated by pine-oak associations, are distinguished: the sandhill community and the sand pine scrub community. Sandhill vegetation typically occurs on a rolling topography of deep, well-drained, weakly washed and sorted sands. Longleaf pine and turkey oak (Quercus laevis) are the respective canopy and subcanopy dominants. The sand pine scrub community is the least fertile and one of the most xeric communities in Florida. It is dominated by sand pine (Pinus clausa), with a dense shrub layer characterized by sclerophyllous species.

2.2.4.2.4 Wetlands

Wetlands include both forested and nonforested areas in which the water table is at, near, or above the land surface for a significant part of the year (Anderson et al. 1976; Texas Instruments, Inc. 1978a). The distribution and areal extent of wetlands in the coastal zone of the Tampa Bay complex are indicated in Figure 2-8. Forested wetlands in the Hillsborough County region are classified under three major categories: swamp forest, bay forest, and brushland or swamp thicket.

Swamp forests are typically dominated by either mixed hardwoods, cypress, or mangroves. Mixed hardwood swamps occur as elongated stands along flowing water such as creeks, rivers, sloughs, and irregularly flooded basins. The characteristic trees of mixed hardwood swamps include red maple (Acer rubrum), water oak (Quercus nigra), laurel oak (Quercus laurifolia), and bald cypress (Taxodium distichum). Deep freshwater habitats containing surface water throughout most or all of the growing season commonly support swamp communities dominated by bald cypress or pond cypress (Taxodium ascendens), with pond cypress occurring on sites having lower pH values. Mangrove swamps occupy the marine littoral zone where regular tidal flushing occurs, and they are characterized by red mangrove (Rhizophora mangle), black mangrove (Avicennia germinans), or white mangrove (Laguncularia racemosa).

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*Here the term hammock refers to hardwoods, either evergreen or deciduous, which have an association with palms. (The term generally refers to a fertile area characterized by hardwood vegetation and humus-rich soil.)

The bay forest or bayhead association is dominated by broadleaf evergreen trees, the most common of which are sweet bay (Magnolia virginiana), swamp bay (Persea palustris), and loblolly bay (Gordonia lasianthus). Bayheads occur in acidic, water-saturated soils that are high in organic matter, and which are found characteristically in depressions in the pine flatwoods region.

Brushlands or swamp thickets include wetland areas dominated by shrubs or low trees. Brushlands typically border the large tree swamps or grow on peat or muck soils that once had been put to agricultural use. Woody plants commonly found in swamp thickets include elderberry (Sambucus simpsonii), buttonbush (Cephalanthus occidentalis), southern willow (Salix caroliniana), and saltbush (Baccharis halimifolia).

Nonforested wetland types include wet prairie, deep freshwater marsh, and salt marsh. Wet prairie communities occur on low, seasonally wet, or flooded soils. Vegetation cover typically consists of grasses, sedges, rushes, and some shrubs (Table 2-14). Wet prairies are normally succeeded by either cypress or mixed hardwood swamps.

Deep freshwater marshes develop along the margins of ponds and lakes, in open marshlands, and in open sloughs where soils are covered by water during most or all of the growing season. They are characterized by emergent or floating-leaf aquatic plants. Floating species are more common in deeper waters (3 to 8 feet). Common species of deep freshwater marshes include cattail (Typha spp.), sawgrass (Cladium jamaicense), lotus (Nelumbo lutea), and arrowhead (Sagittaria spp.).

Salt marshes are plant communities of the intertidal zone that exhibit a distinctive zonation, controlled primarily by the periodic rise and fall of the tide and by other factors such as substrate composition, elevation, pH, and salinity. Smooth cordgrass (Spartina alterniflora) dominates the seaward zone. Black rush (Juncus romerianus) occupies slightly higher ground, typically exhibits the greatest areal extent of any saltmarsh plant, and sometimes occurs in nearly pure stands. A third zone lying above the high tide line is characterized either by saltmeadow cordgrass (Spartina patens) or salt grass (Distichlis spicata).

2.2.4.3 Fauna

2.2.4.3.1 Amphibians and Reptiles

Twenty-four species of amphibians and 67 species of reptiles have been reported in west-central Florida in the region around Hillsborough County (Layne et al. 1977). Eighty-nine of these have ranges that include the Big Bend site (Table 2-15). Three species (i.e., southern fence lizard, Atlantic leatherback, and the Florida redbelly snake) have not been documented in the county. Two subspecies of box turtles (i.e., Florida box turtle and the gulf coast box turtle) could occur in the county, but the distinction between subspecies is usually not made. Also, two subspecies of kingsnake (i.e., Florida kingsnake and eastern kingsnake) could occur in the county, but the distinction is rarely made. Similarly, three subspecies of water snakes of the genus Nerodia and species fasciata (i.e., gulf salt marsh snake, mangrove salt marsh snake, and Florida water snake) could occur in the county, but only *Nerodia fasciata* has been reported. Eleven species of reptiles are endemic or nearly endemic to Florida. They are the Florida redbelly turtle, Florida worm lizard, short-tailed snake, peninsula crowned snake, striped mud turtle, striped crayfish snake, gopher tortoise, Florida softshell, peninsula mole skink, Island glass lizard, and south Florida swamp snake. Two species of amphibians are endemic or nearly endemic to Florida. They are the narrow-striped dwarf siren and the pig frog.

2.2.4.3.1.1 Ranges

Eighty-nine species of amphibians and reptiles have geographic ranges that include the Big Bend site (Table 2-15). These include 26 amphibians and 63 reptiles. Eighty-one of the 89 species have been documented in Hillsborough County (Layne et al. 1977).

Amphibians include a species of amphiuma, 4 species of salamanders, 3 species of sirens, 4 species of toads, 1 species of spadefoot, and 13 species of frogs. Occurrence and abundance of 5 of these species on the Big Bend site are restricted by range limitations. The site is near the southernmost range of the southern dusky salamander, slimy salamander, and lesser siren. If they occur in the area at all, their abundance is low. The giant toad has been reported only from the Tampa area, but it could spread to other areas along the gulf coast in the future. The Florida crawfish or gopher frog is restricted to coastal areas in this part of Hillsborough County.

The greenhouse frog, the only exotic amphibian in the area, was introduced from the West Indies and could occur in the vicinity of the Big Bend site.

The 59 species of reptiles (excluding sea turtles) include 13 turtles, 1 alligator, 2 anoles, 3 skinks, 6 lizards, 33 snakes, and 1 gecko. Eleven of these may not occur on the Big Bend site because of range restrictions. The river or Suwannee cooter is near the southern limits of its range near the site. The only documented population in Hillsborough County occurs near the Lithia Springs and in nearby sections of the Alafia River. The Florida worm lizard, southern fence lizard, short-tailed snake, eastern kingsnake, and peninsula crowned snake are also near their southern range limits near the site. *Nerodia fasciata clarki* (gulf salt marsh snake) occurs mostly north of Hillsborough County along the coast, but it has not been reported from the immediate site region. It is unlikely that it occurs on the site. *Nerodia fasciata compressicauda* (mangrove salt marsh snake) and *Nerodia fasciata pictiventris* (Florida water snake) are both likely to occur near the site. The mangrove salt marsh snake is more coastal and saltwater-oriented, whereas the Florida water snake is more widely distributed in freshwater habitats in west-central Florida. Intergradation of the two subspecies may occur where saltwater and freshwater meet. The Mediterranean gecko and Cuban brown anole are both introduced exotics. Both species occur in isolated populations, usually in urban areas. The anole is found in the Tampa area at present while the gecko is slightly more widespread along the gulf coast.

Four species of sea turtles could occur in waters in or adjacent to Tampa Bay. The Atlantic loggerhead, Atlantic green turtle, and Atlantic ridley have been reported from Hillsborough County. The Atlantic loggerhead is known to nest in Hillsborough County (Layne et al. 1977), but it is considered rare for the area. The Atlantic ridley could also occur in inshore coastal waters, but it is considered rare in the region. The appearance of the Atlantic green turtle is considered irregular in the region, but Long reported a shell in Hillsborough County at Beacon Key in 1975. The Atlantic leatherback would also be very rare in the region. It prefers deep, open water, and would have less chance of occurring near the site than the other three species. Breeding and/or occurrence of any sea turtle near the Big Bend site is unlikely.

2.2.4.3.1.2 Aquatic Habitats

Amphibians and reptiles of the region could occur in terrestrial, freshwater, or saltwater habitats. About one-third of the species have been reported in saltwater habitats, with only the sea turtles being totally restricted to saltwater (except during egg laying).

Although several reptiles can occur in saltwater-brackish habitats, few occur in these areas exclusively. Layne et al. (1977) reported only 2 reptiles, the ornate diamondback terrapin and Nerodia fasciata, as occurring occasionally in coastal, bay, and estuary associations. The mangrove swamp is the only other saltwater-brackish habitat that occurs on the Big Bend site. Layne reported 2 species of amphibians, the green treefrog and southern leopard frog, and 10 species of reptiles (e.g., Florida redbelly turtle, Florida softshell, and rough green snake) as occasionally occurring in mangrove swamps (Table 2-16). The only species that commonly occurs in saltwater-brackish habitats in the region is the ornate diamondback terrapin.

Fifty-two species of amphibians and reptiles could occur in freshwater habitats in the region (i.e., freshwater marshes, lakes and ponds, and streams and rivers). Twenty-three are amphibians and 29 are reptiles (Table 2-16). Species diversity in all three habitats is nearly equal, with an average of about 43 potential species in each. Eleven of the 23 amphibians (e.g., two-toed amphiuma, greater siren, Florida chicken turtle, and the brown water snake) occur only in aquatic habitats. Ten of the 23 species of amphibians could breed in aquatic habitats that occur on the site. The remaining 13 species of amphibians breed in or near other aquatic habitats that are not found on the Big Bend site.

Some of the more common amphibians of the region are the Florida cricket frog, green treefrog, little grass frog, and southern leopard frog. Some common aquatic reptiles of the region are the Florida snapping turtle, peninsula cooter, Florida chicken turtle, stinkpot, and Florida green water snake.

2.2.4.3.1.3 Terrestrial Habitats

Forty-eight species of amphibians and reptiles are found in terrestial habitats at Big Bend including flatwoods; prairies; pasture and croplands; dunes, beaches, and flats; artificial barren land; and urban developments. Twelve species are amphibians and 35 are reptiles (Table 2-16). The greatest diversity of species is expected in the typical flatwoods, where 45 of the potential 48 terrestrial species may occur. All other terrestrial habitats are expected to have less diversity of species.

Of the 12 amphibians found in terrestrial habitats, only the squirrel tree frog is found outside typical flatwoods associations (Table 2-16). Nine of the 12 species are dependent on water during the breeding season but also live in terrestrial habitats the rest of the year. Amphibians that are common in terrestrial habitats are the oak toad, southern toad, pine woods tree frog, squirrel tree frog, and little grass frog. The squirrel tree frog is also common in urban areas.

Of the 35 reptiles that occur in terrestrial habitats in the region, 15 species also occur in aquatic habitats (e.g., Florida cottonmouth, southern black racer, scarlet kingsnake, and rough green snake). Typical terrestrial species are the gopher tortoise, six-lined racerunner, ground skink, eastern diamondback rattlesnake, and eastern coachwhip.

Although typical flatwoods is the most common terrestrial habitat in the region, 23 of the 35 reptiles may occur in other habitats. Only two species, the Mediterranean gecko and Cuban brown anole, are restricted to habitats other than typical flatwoods; they usually occur in urban areas.

Only the six-lined racerunner is expected in artificial barren land and fill areas. Seven species of reptiles could occur in dunes-beaches-flats associations, but the gopher tortoise would be the only relatively common species in these habitats in the region. Eight species could occur in dry prairies, where the southern black racer and eastern diamondback rattlesnake may be fairly common. Of the 15 species occurring in pasture and croplands, only the ground skink would be common. Some fairly common terrestrial reptile species occurring in typical flatwoods are the box turtles, southern black racers, and eastern diamondback rattlesnakes. Terrestrial reptiles in the region are generally uncommon to rare. Low abundance in the region could be caused by limited native habitats, low reproductive rates as compared with some amphibians, and continued habitat disturbance and destruction.

In summary, typically common or abundant amphibians and reptiles that could occur on or near the Big Bend site, if suitable habitat exists, include the Florida cricket frog, oak toad, squirrel tree frog, little grass frog, pig frog, southern leopard frog, peninsula cooter, Florida chicken turtle, stinkpot, Florida softshell, Nerodia fasciata, and peninsula ribbon snake.

2.2.4.3.2 Birds

Approximately 370 species of birds have been reported from the west-central part of Florida around Hillsborough County (Layne et al. 1977). Two hundred ninety-two species, plus 6 subspecies and 5 introduced exotics, have been documented in Hillsborough County (Table 2-17). Most of the birds discussed in this section include only those species using habitats that occur on or near the Big Bend site, and birds that have been documented in Hillsborough County.

2.2.4.3.2.1 Seasonal Occurrence

Of the 292 species reported in Hillsborough County, 39 occur irregularly. These accidental species would not have significant status in the region unless they were species of special status (i.e., white-tailed kite, noddy tern, ivory-billed woodpecker, Bachman's warbler, and Kirtland's warbler). Another 57 species are transients or migrants and would pass through the area during the spring and/or fall. Important groups of transients include raptors (3 species, including the endangered peregrine falcon), shorebirds (10 species), swallows (4 species), and warblers (21 species). The remaining 196 species are either winter residents, summer residents, or year-round residents.

Most birds associated with the Big Bend site are permanent or year-round residents (88 species). Most of these could breed in habitats found on site. Thirty-seven (42 percent) of the 88 species are associated with freshwater or saltwater habitats. This group includes 8 species of raptors. Groups with few representatives of permanent residents are shorebirds (6 species), waterfowl (2 species), warblers (3 species), and sparrows (1 species).

Twenty-three species are expected only in summer. Although most of these breed in the region, some are nonbreeders (e.g., the white pelican and American avocet). In this group of summer residents, only the purple martin, great-crested flycatcher, common nighthawk, chuck-wills-widow, least tern, black-necked stilt, and roseate spoonbill would be relatively common in certain habitats (Table 2-17).

Eighty-five species of birds that have been reported in Hillsborough County in habitats that occur on or near the Big Bend site are expected only in the winter. Nineteen of these are waterfowl. Twenty-four species are other water birds (marsh or wading birds, shorebirds, gulls, and terns). Only 5 species of warblers winter in the region, but there are 21 species of transient warblers. Twelve species of sparrows are winter residents only. Forty-seven species (55 percent) of the wintering birds are associated with freshwater habitats; saltwater habitats; or dunes-beaches-flats associations.

2.2.4.3.2.2 Habitats

Although approximately 31 habitats occur in west-central Florida (Layne et al. 1977), only 11 of these occur on or near the Big Bend site. Eight of these are native habitats, whereas 3 (pasture and croplands, artificial barren lands, and urban) are man-made. Five of these are terrestrial habitats (i.e., typical flatwoods, dry prairie, pasture and croplands, artificial barren lands, and urban). Dunes, beaches, and flats are considered terrestrial in this report. Five others are aquatic (i.e., mangrove swamp, freshwater marsh, lakes and ponds, rivers and streams, and coasts, bays, and estuaries).

One hundred seventy-six of the 292 species occurring in the region can be found in terrestrial habitats (Table 2-17). One hundred fifty-five species could occur in aquatic habitats. Species richness is approximately equal (110) for both freshwater and saltwater areas. Species such as the turkey vulture, bald eagle, marsh hawk, common snipe, ring-billed gull, laughing gull, least tern, eastern phoebe, barn swallow, fish crow, yellow-rumped warbler, common yellowthroat, red-winged blackbird, and boat-tailed grackle are relatively common and utilize both terrestrial and aquatic habitats.

Eighty-one species are commonly found only in terrestrial habitats. Some typical terrestrial species include the American kestrel, bobwhite, mourning dove, common nighthawk, house wren, American robin, and chipping sparrow. Only 60 species are restricted to aquatic habitats. This group generally includes waterfowl and several wading or shorebirds. Many aquatic species are transients or winter birds that periodically occupy freshwater or saltwater marshes, ponds and lakes, rivers and streams, or offshore areas. Some of the more common aquatic species include the horned grebe, pied-billed grebe, brown pelican, anhinga, ring-necked duck, lesser scaup, ruddy duck, red-breasted merganser, common gallinule, and American coot.

Six subspecies have been reported in Hillsborough County in habitats that occur on or near the Big Bend site (Table 2-17). All are permanent residents except the great white heron, which occurs only in the summer. All six subspecies are given special status in Florida and are discussed in the endangered species section of this report (Section 2.8.4). Only the Florida sandhill crane and Florida prairie warbler could be fairly common in suitable habitats that occur on or near the Big Bend site.

Five introduced exotics could occur in the region of the Big Bend site. The monk parakeet and budgerigar are permanent residents. The African crowned crane, flaming parakeet, and canary-winged parakeet are irregulars. These species are not expected in habitats that occur on the Big Bend site.

The greatest diversity of species in the 11 habitats that occur on or near the Big Bend site is expected in the freshwater marshes (93 species). Most of these are wading birds, shorebirds, gulls, or terns. Also, 21 of 42 special status species may occur in freshwater marshes of the region. However, diversity and abundance of these species are expected to be low on the site because marsh habitat is scarce.

Three other habitats have a potentially high species diversity (i.e., typical flatwoods, 81 species; pasture and croplands, 80 species; and dunes, beaches, and flats, 79 species). Some of the common flatwoods species are the bobwhite, mourning dove, common nighthawk, tree swallow, house wren, palm warbler, and chipping sparrow. Species regularly occurring in pasture and croplands are the cattle egret, black vulture, American kestrel (winter only), killdeer, common nighthawk, American robin, common yellowthroat, eastern meadowlark, and savannah sparrow. Great blue herons, semipalmated plovers (winter only), willets, ring-billed gulls, belted kingfishers, and fish crows are a few species that are common in dunes-beaches-flats associations.

Only two habitats have extremely low species diversity: urban areas (10 species) and artificial barren lands (15 species). The rock dove and house sparrow are the only common species occurring in urban areas. The savannah sparrow is the only species considered common in artificial barren lands.

Thirty of the 292 potentially occurring species have been reported in five or more habitat types that occur on or near the Big Bend site. Species occurring in six or more habitats are the cattle egret, turkey vulture, bald eagle, ring-billed gull, laughing gull, gull-billed tern, least tern, belted kingfisher, tree swallow, barn swallow, fish crow, palm warbler, eastern meadowlark, red-winged blackbird, boat-tailed grackle, and savannah sparrow. At least 54 species documented in Hillsborough County are not expected on the Big Bend site because suitable habitat is lacking. Many of these are terrestrial woodland species, especially warblers, and two others have special status (noddy tern and Bachman's warbler). Eighty-one species would be expected in only one habitat and 57 species would be expected in only two habitats. At least 192 of the 292 potentially occurring species (66 percent) have very narrow habitat ranges in this region.

2.2.4.3.3 Mammals

Forty-nine species and 2 subspecies of terrestrial mammals have geographic ranges that include all or part of the region of west-central Florida around Hillsborough County (Layne et al. 1977). As many as 46 species of mammals could occur in Hillsborough County as compared with only 21 species in Charlotte County. Eighty percent of all species of native land mammals in Florida could occur in the west-central Florida region.

Approximately 45 species of land mammals have ranges that include the area around the Big Bend site (Table 2-18). The manatee, an aquatic mammal, also occurs in the area. Ten species are unlikely to occur in the area because the site is near the periphery of their known geographic ranges (e.g., eastern pipistrelle, Florida mouse, and black bear). Other species are not expected because suitable habitats are not found in the area. Important mammalian habitats of the region include swamp forests, marshes and wet meadows, sand pine scrub, sandhills, and mature pine flatwoods with low herbaceous ground cover.

One marsupial species, 3 insectivore species, 8 bat species, 1 edentate species, 2 lagomorph species, 17 rodent species (including 11 mice and rat species), 11 carnivore species, 2 even-toed ungulate species, and 1 siren species could occur on or near the Big Bend site (Table 2-18). Only the coyote, black bear, and Florida panther (mountain lion) have not been positively identified in Hillsborough County.

2.2.4.3.3.1 Ranges

Ten mammals occurring in the region are not expected on the site because of range limitations. The southeastern myotis, eastern pipistrelle, golden mouse, and old-field mouse are near the southern limits of their known ranges in the Big Bend area. The coyote and black bear occur in the region, although no permanent populations are believed to exist in Hillsborough County. The gray squirrel, Florida mouse, round-tailed muskrat, and nutria occur in Hillsborough County, but their occurrence is perhaps restricted more by habitat than by range.

The gray squirrel occurs over much of Florida, but is usually restricted to heavily forested bottomlands and big stands of mature hardwoods, especially oak hammocks. The Florida mouse is endemic to Florida, and has one of the narrowest habitat ranges of any species in the state. It occurs in low numbers over much of Hillsborough County, where suitable habitat exists. Its preferred habitat is early successional sand pine scrub, but it also occurs in longleaf pine-turkey oak, south Florida slash pine-turkey oak, and scrubby flatwoods. The round-tailed muskrat occurs in scattered populations over much of Florida. Freshwater marshes and vegetated lake and pond shorelines are its primary habitats, although it sometimes occurs in salt marshes. It is generally uncommon and spotty in occurrence in the region. Nutria occur in scattered populations over much of western and northern Florida. They occur in freshwater and coastal habitats, but are generally more common in polluted waters, especially ponds formed by dairy farm runoff (Layne et al. 1977). A well-established population exists at Brandon, Hillsborough County. This species is an escaped exotic from commercial nutria farms. They could have an adverse effect on native flora and fauna.

2.2.4.3.3.2 Habitats

Although 31 habitats could occur in west-central Florida, only about 11 of these occur on or near the Big Bend site (Table 2-19). Habitat restrictions limit mammal diversity and abundance regionally. Habitats such as those named in the following brief list would have little diversity of species (Table 2-19): lakes and ponds; rivers and streams; coasts, bays, and estuaries; artificial barren lands; dunes, flats, and beaches; and mangrove swamps. The lowest diversity is expected in the coastal areas, bays, and estuaries, where only two species could occur (i.e., river otter and manatee). Typical flatwoods, pasture and cropland, urban areas, dry prairie, and freshwater marsh would have greater diversity of species. The greatest diversity is expected in flatwoods (29 species) and in pasture and croplands (28 species).

Some of the more common species expected in flatwoods are the northern yellow bat, eastern cottontail, hispid cotton rat, and raccoon. Species relatively common in pasture and croplands are the eastern cottontail, hispid cotton rat, northern yellow bat, eastern mole, and nine-banded armadillo.

Nine of the 46 species are expected in 5 or more of the 11 habitats. Raccoons may occur in 10 of 11 habitats, the opossum in 8 habitats, armadillo and eastern cottontail in 7 habitats, cotton rat and house mouse in 6 habitats, and the rice rat, river otter, and bobcat in 5 habitats (Table 2-19). Four species are not expected on the site because of a lack of suitable habitat (i.e., Rafinesque's big-eared bat, Florida mouse, golden mouse, and eastern woodrat). Eight species could occur in only one habitat (e.g., eastern mole, big brown bat, and fox squirrel).

Species that are probably rare in the region include the eastern pipistrelle, Seminole bat, big brown bat, black bear, long-tailed weasel, and Florida panther.

Several species in the region are considered common or abundant in their preferred habitats. The Virginia opossum may be most common in typical flatwoods. The least shrew, nine-banded armadillo, and eastern mole are common in flatwoods, dry prairies, and in pasture and croplands. The eastern cottontail is abundant in flatwoods and in pasture and croplands. The marsh rice rat is common in the mangrove swamp, freshwater marsh, and in wetter pasture and cropland areas. The hispid cotton rat is abundant in flatwoods, dry prairies and pasture and croplands. The raccoon is common or abundant in almost every habitat. The white-tailed deer and wild boar are common in flatwoods, dry prairies, pasture and croplands, and freshwater marshes, although their populations are somewhat isolated in the county.

Table 2-10. Common herbaceous plants in old fields[a]

Common name	Scientific name
Crabgrass	*Digitaria sanguinalis*
Bermudagrass	*Cynodon dactylon*
Sand-spurs	*Cenchrus* spp.
Ragweed	*Ambrosia* sp.
Cudweed	*Gnaphalium* spp.
Foxtail	*Setaria* spp.
Dog-fennel	*Eupatorium* spp.
Beard-grass, broom-sedge	*Andropogon* spp.
Lovegrass	*Eragrostis* spp.
Galingale	*Cyperus* spp.
Paspalum	*Paspalum* spp.
Panic grass	*Panicum* spp.
Button-weed	*Diodia teres*
Toadflax	*Linaria canadensis*

[a] Adapted from Wunderlin et al. (1975).

Table 2-11. Common woody and herbaceous plants associated with cabbage palm hammocks[a]

Common name	Scientific name
Woody species	
Cabbage palm	Sabal palmetto
Blue palm	Sabal minor
Water oak	Quercus nigra
Live oak	Quercus virginiana
Laurel oak	Quercus laurifolia
Sweet gum	Liquidambar styraciflua
Florida elm	Ulmus floridana
Slash pine	Pinus elliottii
Longleaf pine	Pinus palustris
Greenbrier	Smilax spp.
Poison ivy	Rhus radicans
Pignut hickory	Carya glabra
Red maple	Acer rubrum
Pepper vine	Ampelopsis arborea
Swamp redbay	Persea palystris
Loblolly bay	Gordonia lasiantha
Swamp bay	Magnolia virginiana
Black haw	Viburnum obovatum
Possum haw	Viburnum nudum
Rattan vine	Berchemia scandens
Saw palmetto	Serenoa repens
Wax myrtle	Myrica cerifera
Ilex	Ilex spp.
Herbaceous species	
Carpetgrass	Axonopus spp.
Coinwort	Centella asiatica
Panic grass	Panicum spp.
Paspalum	Paspalum spp.
Beak-rush	Rynchospora spp.
Button snakeroots	Eryngium baldwinii
Melochia	Melochia hirsuta
Twinflowers	Dyschoriste oblongifolia
Musky mint	Hyptis alata
Ruellia	Ruella caroliniensis
Ferns (several species)	

[a] Adapted from Wunderlin et al. (1975).

Table 2-12. Characteristic plants of the live oak hammock[a]

Common name	Scientific name
Woody species	
Live oak	*Quercus virginiana*
Bluejack oak	*Quercus incana*
Laurel oak	*Quercus laurifolia*
Myrtle oak	*Quercus myrtifolia*
Chapmans oak	*Quercus chapmanii*
Cabbage palm	*Sabal palmetto*
Saw palmetto	*Serenoa repens*
American holly	*Ilex opaca*
Redbay	*Persea borbonia*
Greenbrier	*Smilax* spp.
Blueberry	*Vaccinium* spp.
Dwarf sumac	*Rhus copallina*
Staggerbush	*Lyonia fruticosa*
Beautybush	*Callicarpa americana*
Wild grape	*Vitis* sp.
Herbaceous species	
Panic grass	*Panicum* spp.
Beard grass	*Andropogon* spp.
Pinweed	*Lechea* sp.
Goldenrod	*Solidago chapmanii*
Golden-aster	*Heterotheca* sp.
Tick clover	*Desmodium canescens*
Partridge pea	*Cassia fasciculata*

[a] Adapted from Wunderlin et al. (1975).

Table 2-13. Characteristic plants of the mesic hammock[a]

Common name	Scientific name
Woody species	
Southern magnolia	*Magnolia grandiflora*
American holly	*Ilex opaca*
Laurel oak	*Quercus laurifolia*
Live oak	*Quercus virginiana*
Water oak	*Quercus nigra*
Pignut hickory	*Carya glabra*
Cabbage palm	*Sabal palmetto*
Saw palmetto	*Serenoa repens*
Black cherry	*Prunus serotina*
Redbay	*Persea borbonia*
Blueberry	*Vaccinium* spp.
Ilex	*Ilex* spp.
Lyonia	*Lyonia* spp.
Beautybush	*Callicarpa americana*
Greenbrier	*Smilax* spp.
Wild olive	*Osmanthus americana*
Herbaceous species	
Panic grass	*Panicum* spp.
Partridge berry	*Mitchella repens*
Nut-rush	*Scleria* spp.
Sedge	*Carex* spp.

[a] Adapted from Wunderlin et al. (1975).

Table 2-14. Characteristic plants of the wet prairie[a]

Common name	Scientific name
Woody species	
Saw palmetto	*Serenoa repens*
Sand cypress	*Hypericum fasciculatum*
Corkwood	*Stillingia aquatica*
Herbaceous species	
Wiregrass	*Aristida* spp.
White top	*Dichromena* spp.
Broomsedge, beard-grass	*Andropogon* spp.
Beak-rush	*Rhynchospora* spp.
Panic grass	*Panicum* spp.
Maidencane	*Panicum hemitomon*
Lovegrass	*Eragrostis elliottii*
Cattail	*Typha* spp.
Spike rush	*Eleocharis* spp.
Bulrush	*Scirpus* spp.
Fringe rush	*Fimbristylis* spp.
Sawgrass	*Cladium jamaicense*
Pickerel-weed	*Pontederia cordata*
Arrowhead	*Sagittaria* spp.
Bladderwort	*Utricularia* spp.
Yellow-eyed grass	*Xyris* spp.
Pennywort	*Hydroctyle* spp.
Meadow beauty	*Rhexia* spp.
Coinwort	*Centella asiatica*
Rush	*Juncus* spp.
Sedge	*Carex* spp.
Galingale	*Cyperus* spp.
Pipewort	*Eriocaulon* spp.
Yellow pond lily, spatterdock	*Nuphar luteum*
Cordgrass	*Spartina* spp.

[a] Adapted from Wunderlin et al. (1975).

Table 2-15. Amphibians and reptiles whose geographic ranges include the Big Bend site[a] (Sheet 1 of 3)

Common name[b]	Scientific name	Occurrence		
Two-toed amphiuma	*Amphiuma means*	L		
Southern dusky salamander[c]	*Desmognathus auriculatus*	L		
Dwarf salamander	*Eurycea quadridigitata*	L		
Peninsula newt	*Notophthalmus viridescens piaropicola*	L		
Slimy salamander[c]	*Plethodon glutinosus glutinosus*	L		
Narrow-striped dwarf siren	*Pseudobranchus striatus axanthus*	L		
Eastern lesser siren[c]	*Siren intermedia intermedia*	L		
Greater siren	*Siren lacertina*	L		
Florida cricket frog	*Acris gryllus dorsalis*	L		
Giant toad[c,d]	*Bufo marinus*	L		
Oak toad	*Bufo quercicus*	L		
Southern toad	*Bufo terrestris*	L	W	B
Eastern narrowmouth toad	*Gastrophryne carolinensis*	L	W	B
Green tree frog	*Hyla cinerea*	L	W	B
Pine woods tree frog	*Hyla femoralis*	L		B
Barking tree frog	*Hyla gratiosa*	L		
Squirrel tree frog	*Hyla squirella*	L	W	B
Greenhouse frog[e]	*Eleutherodactylus planirostris*	L		B
Little grass frog	*Limnaoedus ocularis*	L		
Florida chorus frog	*Pseudacris nigrita verrucosa* }	L		
Ornate chorus frog	*Pseudacris ornata* }			
Florida crawfish frog[c,f]	*Rana areolata aesopus*	L		
Bullfrog	*Rana catesbeiana*	L	W	B
Pig frog	*Rana grylio*	L		
Southern leopard frog	*Rana sphenocephala*	L	W	B
Eastern spadefoot	*Scaphiopus holbrooki holbrooki*	L		
Florida snapping turtle	*Chelydra serpentina osceola*	L		
River cooter[c,g]	*Chrysemys concinna*	L		
Peninsula cooter	*Chrysemys floridana peninsularis*	L	W	B
Florida redbelly turtle	*Chrysemys nelsoni*	L		
Florida chicken turtle	*Deirochelys reticularia chrysea*	L		
Gopher tortoise	*Gopherus polyphemus*	L		B
Striped mud turtle	*Kinosternon bauri palmarum*	L	W	B
Florida mud turtle	*Kinosternon subrubrum steindachneri*	L		
Ornate diamondback terrapin	*Malaclemys terrapin macrospilota*	L		B
Stinkpot	*Sternotherus odoratus*	L		
Florida box turtle	*Terrapene carolina bauri*	L		B
Gulf coast box turtle	*Terrapene carolina major*		W	
Florida softshell	*Trionyx ferox*	L		
American alligator	*Alligator mississippiensis*	L		B
Green anole	*Anolis carolinensis carolinensis*	L	W	B

Note: See abbreviations, footnotes, and note at end of table.

Table 2-15. Amphibians and reptiles whose geographic ranges include the Big Bend site[a] (Sheet 2 of 3)

Common name[b]	Scientific name	Occurrence		
Six-lined racerunner	*Cnemidophorus sexlineatus sexlineatus*	L	W	B
Peninsula mole skink	*Eumeces egregius onocrepis*	L		
Southeastern five-lined skink	*Eumeces inexpectatus*	L	W	B
Eastern slender glass lizard	*Ophisaurus attenuatus longicaudus*	L		
Island glass lizard	*Ophisaurus compressus*	L		
Eastern glass lizard	*Ophisaurus ventralis*	L		
Florida worm lizard[c]	*Rhineura floridana*	L		
Southern fence lizard[c]	*Sceloporus undulatus undulatus*			
Ground skink	*Scincella lateralis*	L	W	B
Florida cottonmouth	*Agkistrodon piscivorus conanti*	L		
Florida scarlet snake	*Cemophora coccinea coccinea*	L		
Southern black racer	*Coluber constrictor priapus*	L	W	B
Eastern diamondback rattlesnake	*Crotalus adamanteus*	L	W	B
Southern ringneck snake	*Diadophis punctatus punctatus*	L		
Eastern indigo snake	*Drymarchon corais couperi*	L	W	B
Corn snake	*Elaphe guttata guttata*	L		B
Yellow rat snake	*Elaphe obsoleta quadrivittata*	L	W	
Eastern mud snake	*Farancia abacura abacura*	L		
Eastern hognose snake	*Heterodon platyrhinos*	L		
Southern hognose snake	*Heterodon simus*	L		
Florida kingsnake	*Lampropeltis getulus floridana* }	L		
Eastern kingsnake[c]	*Lampropeltis getulus getulus* }			
Scarlet kingsnake	*Lampropeltis triangulum elapsoides*	L		B
Eastern coachwhip	*Masticophis flagellum flagellum*	L		
Eastern coral snake	*Micrurus fulvius fulvius*	L		
Florida green water snake	*Nerodia cyclopion floridana*	L		
Gulf salt marsh snake[c]	*Nerodia fasciata clarki*			
Mangrove salt marsh snake[c]	*Nerodia fasciata compressicauda* }	L		
Florida water snake	*Nerodia fasciata pictiventris* }		W	B
Brown water snake	*Nerodia taxispilota*	L		
Rough green snake	*Opheodrys aestivus*	L		B
Florida pine snake	*Pituophis melanoleucus mugitus*	L		
Striped crayfish snake	*Regina alleni*	L		
Pine woods snake	*Rhadinaea flavilata*	L		
South Florida swamp snake	*Seminatrix pygaea cyclas*	L		
Dusky pigmy rattlesnake	*Sistrurus miliarius barbouri*	L		
Short-tailed snake[c]	*Stilosoma extenuatum*	L		
Florida brown snake	*Storeria dekayi victa*	L		
Florida redbelly snake	*Storeria occipitomaculata obscura*			
Peninsula crowned snake[c]	*Tantilla relicta relicta*	L		

Note: See abbreviations, footnotes, and note at end of table.

Table 2-15. Amphibians and reptiles whose geographic ranges include the Big Bend site[a] (Sheet 3 of 3)

Common name[b]	Scientific name	Occurrence		
Peninsula ribbon snake	*Thamnophis sauritus sackeni*	L		B
Eastern garter snake	*Thamnophis sirtalis sirtalis*	L		B
Mediterranean gecko[c,d]	*Hemidactylus turcicus turcicus*	L		
Cuban brown anole[c,d]	*Anolis sagrei sagrei*	L		
Atlantic loggerhead[h]	*Caretta caretta caretta*	L		
Atlantic green turtle[h]	*Chelonia mydas mydas*	L		B
Atlantic leatherback[h]	*Dermochelys coriacea coriacea*			
Atlantic ridley[h]	*Lepidochelys kempi*	L		
Total species 89				
Total species on site 18		81	18	27

Abbreviations:

L = reported in Hillsborough County by Layne et al. (1977).
W = Long (1974a,b) and Wunderlin et al. (1977).
B = Long (1975), from Beacon Key, Florida.

} = Indicates where one of two or three subspecies was reported, but exact subspecies is unknown.

[a] Ranges from Conant (1975).

[b] Nomenclature from Collins et al. (1978).

[c] Site is near the periphery of the known range of the species.

[d] Exotic species that occur in isolated populations primarily in the Tampa area.

[e] Greenhouse frog not listed by Collins et al. (1978).

[f] Also called Florida gopher frog.

[g] The subspecies, Suwannee cooter (*Chrysemys concinna suwanniensis*), has been reported in Hillsborough County only from the Alafia River.

[h] Sea turtle.

Note: No herpetofauna survey findings were reported by Stone & Webster Engineering Corporation (1972) for the Big Bend site.

Table 2-16. Relative abundance of amphibians and reptiles in habitats that occur on or near the Big Bend site[a] (Sheet 1 of 3)

Common name	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
					Amphibians							
Two-toed amphiuma	-	-	-	-	U	-	-	-	C	U	-	3
Southern dusky salamander	-	-	-	-	-	-	-	-	R	R	-	2
Dwarf salamander	-	-	-	-	R	-	-	-	U	U	-	3
Peninsula newt	-	-	-	-	R	-	-	-	U	U	-	3
Slimy salamander	-	-	-	-	-	-	-	-	-	-	-	0
Narrow-striped dwarf siren	-	-	-	-	C	-	-	-	U	R	-	3
Eastern lesser siren	-	-	-	-	-	-	-	-	C	U	-	2
Greater siren	-	-	-	-	C	-	-	-	C	U	-	3
Florida cricket frog	-	-	-	-	A	-	-	-	A	U	-	3
Giant toad	-	-	-	-	-	-	-	-	B?	-	-	1
Oak toad	A	-	-	-	B	-	-	-	B	-	-	3
Southern toad	C	-	-	-	R	-	-	-	B	-	-	3
Eastern narrowmouth toad	C	-	-	-	B	-	-	-	B	B	-	4
Green tree frog	-	U	-	-	C	-	-	-	C	A	-	4
Pine woods tree frog	A	-	-	-	B	-	-	-	B	B	-	4
Barking tree frog	U	-	-	-	B	-	-	-	B	B	-	4
Squirrel tree frog	C	-	-	-	B	-	-	C	B	B	-	5
Greenhouse frog	U	-	-	-	-	-	-	-	-	-	-	1
Little grass frog	A	-	-	-	C	-	-	-	A	C	-	4
Florida chorus frog	U	-	-	-	B	-	-	-	B	B	-	4
Ornate chorus frog												
Florida crawfish frog	V	-	-	-	B	-	-	-	B	-	-	3
Bullfrog	-	-	-	-	U	-	-	-	C	C	-	3
Pig frog	-	-	-	-	C	-	-	-	C	C	-	3
Southern leopard frog	U	R	-	-	A	-	-	-	A	C	-	5
Eastern spadefoot	U	-	-	-	B	-	-	-	B	-	-	3
Subtotal amphibians 26	12	2	0	0	20	0	0	1	23	18	0	
					Reptiles							
Florida snapping turtle	-	-	-	-	C	-	-	-	C	C	-	3
River cooter	-	-	-	-	-	-	-	-	-	R	-	1
Peninsula cooter	-	-	-	-	C	-	-	-	A	C	-	3
Florida redbelly turtle	-	U	-	-	C	-	-	-	U	U	-	4
Florida chicken turtle	-	-	-	-	C	-	-	-	C	C	-	3
Gopher tortoise	U	-	-	-	-	C	-	-	-	-	-	2
Striped mud turtle	-	U	-	-	U	-	-	-	C	U	-	4
Florida mud turtle	-	-	-	-	U	-	-	-	U	R	-	3

Note: See abbreviations and footnotes at end of table.

Table 2-16. Relative abundance of amphibians and reptiles in habitats that occur on or near the Big Bend site[a] (Sheet 2 of 3)

Common name	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
					Reptiles (continued)							
Ornate diamondback terrapin	-	C	-	-	-	-	-	-	-	V	C	3
Stinkpot	-	-	-	-	C	-	-	-	C	C	-	3
Florida box turtle												
Gulf Coast box turtle	C	R	U	R	-	-	-	-	-	-	-	4
Florida softshell	-	R	-	-	C	-	-	-	C	C	-	4
American alligator	-	U	-	-	C	-	-	-	C	C	-	4
Green anole	U	-	-	U	U	-	-	-	-	-	-	3
Six-lined racerunner	U	-	-	U	-	U	U	-	-	-	-	4
Peninsula mole skink	-	-	-	-	-	-	-	-	-	-	-	0
Southeastern five-lined skink	U	U	-	R	-	U	-	-	-	-	-	4
Eastern slender glass lizard	R	-	U	U	-	-	-	-	-	-	-	3
Island glass lizard	R	-	-	-	-	U	-	-	-	-	-	2
Eastern glass lizard	U	-	R	R	-	R	-	-	-	-	-	4
Florida worm lizard	R	-	-	U	-	-	-	-	-	-	-	2
Southern fence lizard	U	-	-	-	-	-	-	-	-	-	-	1
Ground skink	R	-	-	C	-	-	-	-	-	-	-	2
Florida cottonmouth	R	-	-	U	C	-	-	-	C	U	-	5
Florida scarlet snake	R	-	-	-	-	-	-	-	-	-	-	1
Southern black racer	C	-	C	A	U	-	-	-	-	-	-	4
Eastern diamondback rattlesnake	C	-	C	U	-	-	-	-	-	-	-	3
Southern ringneck snake	U	-	-	-	C	-	-	-	-	R	-	3
Eastern indigo snake	U	V	R	-	-	-	-	-	-	-	-	3
Corn snake	U	-	-	U	-	-	-	-	-	-	-	2
Yellow rat snake	U	-	-	U	R	-	-	-	R	-	-	4
Eastern mud snake	-	-	-	-	C	-	-	-	U	R	-	3
Eastern hognose snake	U	-	-	-	-	-	-	-	-	-	-	1
Southern hognose snake	R	-	R	-	-	-	-	S	-	-	-	3
Florida kingsnake	U	-	-	-	-	-	-	-	R	R	-	3
Eastern kingsnake												
Scarlet kingsnake	R	-	-	-	-	-	-	-	R	-	-	2
Eastern coachwhip	U	-	R	R	-	-	-	-	-	-	-	3
Eastern coral snake	R	-	-	-	-	-	-	-	-	-	-	1
Florida green water snake	-	-	-	-	C	-	-	-	C	U	-	3
Gulf salt marsh snake												
Mangrove salt marsh snake	-	U	-	-	A	-	-	-	A	A	S	5

Note: See abbreviations and footnotes at end of table.

Table 2-16. Relative abundance of amphibians and reptiles in habitats that occur on or near the Big Bend site[a] (Sheet 3 of 3)

Common name	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Reptiles (continued)												
Florida water snake												
Brown water snake	-	-	-	-	-	-	-	-	U	C	-	2
Rough green snake	U	R	-	-	-	-	-	-	R	-	-	3
Florida pine snake	R	-	-	-	-	-	-	-	-	-	-	1
Striped crayfish snake	-	-	-	-	C	-	-	-	C	U	-	3
Pine woods snake	U	-	-	-	-	-	-	-	-	-	-	1
South Florida swamp snake	-	-	-	-	U	-	-	-	U	R	-	3
Dusky pygmy rattlesnake	U	-	-	R	U	-	-	-	U	-	-	4
Short-tailed snake	-	-	-	-	-	-	-	-	-	-	-	0
Florida brown snake	R	-	-	-	R	-	-	-	R	-	-	3
Florida redbelly snake	-	-	-	-	-	-	-	-	-	-	-	0
Peninsula crowned snake	V	-	-	-	-	-	-	-	-	-	-	1
Peninsula ribbon snake	U	-	-	-	A	R	-	-	C	C	-	5
Eastern garter snake	R	-	-	-	C	R	-	-	U	U	-	5
Mediterranean gecko	-	-	-	-	-	-	-	R	-	-	-	1
Cuban brown anole	-	-	-	-	-	-	-	U	-	-	-	1
Subtotal reptiles 59	33	10	8	15	23	7	1	3	24	22	2	
Total species[b] 85	45	12	8	15	43	7	1	4	47	40	2	

Abbreviations:
- A = abundant.
- C = common.
- U = uncommon.
- R = rare.
- V = very rare.
- S = population status questionable.
- B = breeding habitat.
- ? = habitats for subspecies were undifferentiated.

[a] From Layne et al. (1977).

[b] This total does not include four species of sea turtles (i.e., Atlantic leatherback, Atlantic loggerhead, Atlantic Ridley, and Atlantic green turtle). Open seas, the Gulf of Mexico, and Tampa Bay are habitats where these species are expected.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 1 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
						Native species							
Common loon	W	-	-	-	-	-	-	-	-	R	-	C	2
Red-throated loon	I	-	-	-	-	-	-	-	-	-	-	V	1
Red-necked grebe	I	-	-	-	-	-	-	-	-	-	-	V	1
Horned grebe	W	-	-	-	-	-	-	-	-	R	-	A	2
Western grebe	I	-	-	-	-	-	-	-	-	V	-	V	2
Pied-billed grebe	P	-	-	-	-	U	-	-	-	C	U	R	4
White pelican	P	-	-	-	-	-	U	-	-	R	-	U	3
Brown pelican	P	-	U	-	-	-	C	-	-	V	-	A	4
Brown booby	I	-	-	-	-	-	-	-	-	-	-	V	1
Double-crested cormorant	P	-	U	-	-	-	U	-	-	U	R	A	5
Anhinga	P	-	R	-	-	C	-	-	-	C	C	-	4
Magnificent frigate-bird	S	-	U	-	-	-	-	-	-	-	-	C	2
Great blue heron	P	-	V	V	-	C	C	-	-	-	-	-	4
Green heron	P	-	U	-	-	U	-	-	-	-	-	-	2
Little blue heron	P	-	U	-	-	C	R	-	-	-	-	-	3
Cattle egret	P	-	U	U	A	R	-	V	R	-	-	-	6
Reddish egret	S	-	-	-	-	V	R	-	-	-	-	-	2
Great egret	P	-	U	-	V	C	V	-	-	-	-	-	4
Snowy egret	P	-	U	-	-	C	U	-	-	-	-	-	3
Louisiana heron	P	-	U	-	-	C	R	-	-	-	-	-	3
Black-crowned night heron	P	-	U	-	-	C	R	-	-	-	-	-	3
Yellow-crowned night heron	P	-	C	-	-	U	C	-	-	-	-	-	3
Least bittern	P	-	-	-	-	C	-	-	-	-	-	-	1
American bittern	W	-	-	-	-	U	-	-	-	-	-	-	1
Wood stork	P	-	U	-	-	U	U	-	-	-	-	-	3
Glossy ibis	P	-	-	-	-	U	-	-	-	-	-	-	1
White ibis	P	-	C	-	U	U	C	-	-	-	-	-	4
Scarlet ibis	I	-	V	-	-	-	-	-	-	-	-	-	1
Roseate spoonbill	S	-	U	-	-	R	C	-	-	-	-	-	3
American flamingo	I	-	-	-	-	-	V	-	-	-	-	-	1
Whistling swan	I	-	-	-	-	-	-	-	-	-	-	V	1
Canada goose	I	-	-	-	-	-	-	-	-	V	-	V	2
Brant	I	-	-	-	-	-	-	-	-	-	-	V	1
Snow goose	I	-	-	-	-	-	-	-	-	-	V	V	2
Fulvous whistling-duck	T	-	-	-	-	-	-	-	-	-	-	U	1
Ruddy sheld-duck	I	-	-	-		-	-	-	-	V	-	-	1

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 2 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
						Native species (continued)							
Mallard	W	-	-	-	-	-	-	-	-	-	-	U	1
Black duck	W	-	-	-	-	-	-	-	-	-	-	R	1
Mottled duck	P	-	-	-	-	U	-	-	-	U	R	U	4
Gadwall	W	-	-	-	-	-	-	-	-	V	V	U	3
Pintail	W	-	-	-	-	-	-	-	-	R	V	C	3
Green-winged teal	W	-	-	-	-	U	-	-	-	R	R	C	4
Blue-winged teal	W	-	-	-	-	U	-	-	-	U	R	C	4
European widgeon	I	-	-	-	-	-	-	-	-	-	-	V	1
American widgeon	W	-	-	-	-	C	-	-	-	U	R	C	4
Northern shoveler	W	-	-	-	-	U	-	-	-	R	V	C	4
Wood duck	P	-	C	-	-	V	-	-	-	U	U	-	4
Redhead	W	-	-	-	-	-	-	-	-	U	U	U	3
Ring-necked duck	W	-	-	-	-	R	-	-	-	A	C	-	3
Canvasback	W	-	-	-	-	V	-	-	-	U	V	C	4
Greater scaup	I	-	-	-	-	-	-	-	-	-	-	V	1
Lesser scaup	W	-	-	-	-	-	-	-	-	C	U	A	3
Bufflehead	W	-	-	-	-	-	-	-	-	-	-	R	1
Oldsquaw	W	-	-	-	-	-	-	-	-	-	-	R	1
Common eider	I	-	-	-	-	-	-	-	-	-	-	V	1
White-winged scoter	I	-	-	-	-	-	-	-	-	-	-	V	1
Ruddy duck	W	-	-	-	-	-	-	-	-	U	R	A	3
Hooded merganser	W	-	-	-	-	-	-	-	-	R	U	V	3
Common merganser	I	-	-	-	-	-	-	-	-	-	-	V	1
Red-breasted merganser	W	-	-	-	-	-	-	-	-	R	-	A	2
Turkey vulture	P	C	V	C	C	R	-	R	R	-	-	-	7
Black vulture	P	U	-	A	A	R	-	R	-	-	-	-	5
White-tailed kite	I	-	-	-	V	-	-	-	-	-	-	-	1
Swallow-tailed kite	S	U	-	-	-	-	-	-	-	-	-	-	1
Sharp-shinned hawk	W	U	U	-	-	-	R	-	-	-	-	-	3
Cooper's hawk	W	U	-	-	-	-	V	-	-	-	-	-	2
Red-tailed hawk	P	C	-	C	U	V	-	-	-	-	-	-	4
Red-shouldered hawk	P	R	-	-	R	U	-	-	-	-	-	-	3
Broad-winged hawk	T	-	-	-	-	-	-	-	-	-	-	-	0
Short-tailed hawk	P	V	-	-	-	-	-	-	-	-	-	-	1
Bald eagle	P	U	R	V	V	U	-	-	-	R	V	R	8
Marsh hawk	W	R	R	U	U	U	-	-	-	-	-	-	5
Osprey	P	-	U	-	-	R	-	-	-	R	R	C	5
Caracara	P	V	-	U	U	-	-	-	-	-	-	-	3
Peregrine falcon	T	-	-	-	-	-	R	-	-	-	-	R	2
Merlin	T	-	-	-	R	-	R	-	-	-	-	-	2
American kestrel	W	U	-	C	A	-	U	R	-	-	-	-	5

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 3 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Native species (continued)													
Bobwhite	P	C	–	V	A	–	–	–	–	–	–	–	3
Turkey	P	U	–	R	U	–	–	–	–	–	–	–	3
Sandhill crane	W	V	–	R	U	U	–	–	–	–	–	–	4
Limpkin	P	–	–	–	–	U	–	–	–	R	U	–	3
King rail	P	–	–	–	V	C	–	–	–	V	–	–	3
Clapper rail	P	–	C	–	–	–	V	–	–	–	–	–	2
Virginia rail	W	–	–	–	–	U	–	–	–	–	–	–	1
Sora	W	–	–	–	–	A	–	–	–	–	–	–	1
Purple gallinule	S	–	–	–	–	R	–	–	–	U	R	–	3
Common gallinule	P	–	–	–	–	C	–	–	–	A	A	R	4
American coot	P	–	–	–	–	C	–	–	–	A	A	C	4
American oyster-catcher	P	–	–	–	–	–	U	–	–	–	–	–	1
Semipalmated plover	W	–	–	–	–	–	C	–	–	V	–	–	2
Piping plover	W	–	–	–	–	–	U	–	–	–	–	–	1
Wilson's plover	P	–	–	–	–	–	C	–	–	–	–	–	1
Killdeer	P	–	–	U	C	U	R	–	–	–	–	–	4
American golden plover	T	–	–	–	–	–	V	–	–	–	–	–	1
Black-bellied plover	P	–	–	–	–	V	C	–	–	–	–	–	2
Ruddy turnstone	W	–	–	–	–	–	C	–	–	–	–	–	1
American woodcock	W	–	–	–	R	–	–	–	–	–	–	–	1
Common snipe	W	R	–	V	U	A	–	–	–	–	–	–	4
Long-billed curlew	T	–	–	–	–	V	R	–	–	–	–	–	2
Whimbrel	T	–	–	–	–	R	U	–	–	–	–	–	2
Upland sandpiper	T	–	–	R	R	–	–	–	–	–	–	–	2
Spotted sandpiper	W	–	–	–	–	V	C	–	–	–	–	–	2
Solitary sandpiper	T	–	–	–	R	R	–	–	–	–	–	–	2
Greater yellowlegs	W	–	–	–	U	U	C	–	–	–	–	–	3
Lesser yellowlegs	W	–	–	–	U	U	C	–	–	–	–	–	3
Willet	P	–	–	–	–	–	A	–	–	–	–	–	1
Red knot	W	–	–	–	–	–	C	–	–	–	–	–	1
Pectoral sandpiper	T	–	–	–	–	V	U	–	–	–	–	–	2
White-rumped sandpiper	T	–	–	–	–	V	U	–	–	–	–	–	2
Baird's sandpiper	I	–	–	–	–	V	V	–	–	–	–	–	2
Least sandpiper	W	–	–	–	–	U	A	–	–	–	–	–	2
Curlew sandpiper	I	–	–	–	–	V	V	–	–	–	–	–	2
Dunlin	W	–	–	–	–	V	A	–	–	–	–	–	2
Semipalmated sandpiper	T	–	–	–	–	V	A	–	–	–	–	–	2

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 4 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Native species (continued)													
Western sandpiper	W	-	-	-	-	V	A	-	-	-	-	-	2
Sanderling	W	-	-	-	-	V	A	-	-	-	-	-	2
Short-billed dowitcher	W	-	-	-	-	V	A	-	-	-	-	-	2
Long-billed dowitcher	W	-	-	-	-	R	V	-	-	-	-	-	2
Stilt sandpiper	T	-	-	-	-	V	U	-	-	-	-	-	2
Marbled godwit	W	-	-	-	-	-	U	-	-	-	-	-	1
Hudsonian godwit	I	-	-	-	-	-	V	-	-	-	-	-	1
American avocet	P	-	-	-	-	V	U	-	-	-	-	U	3
Black-necked stilt	S	-	-	-	V	C	C	-	-	R	V	-	5
Wilson's phalarope	T	-	-	-	-	-	U	-	-	-	-	U	2
Northern phalarope	I	-	-	-	-	-	-	-	-	-	-	V	1
Great black-backed gull	W	-	-	-	-	-	U	-	-	-	-	-	1
Lesser black-backed gull	I	-	-	-	-	-	R	-	-	-	-	R	2
Herring gull	W	-	-	-	-	-	C	-	-	U	V	C	4
Ring-billed gull	W	-	-	-	V	V	A	U	R	C	U	A	8
Black-headed gull	I	-	-	-	-	-	-	-	-	-	-	V	1
Laughing gull	P	-	-	-	-	-	A	R	V	U	V	A	6
Bonaparte's gull	W	-	-	-	-	-	U	-	-	U	-	U	3
Gull-billed tern	S	-	-	V	V	V	V	V	V	V	V	V	9
Forster's tern	P	-	-	-	-	R	A	-	-	U	U	A	5
Common tern	W	-	-	-	-	-	U	-	-	V	-	U	3
Least tern	S	-	-	-	-	V	C	U	R	U	U	C	7
Royal tern	P	-	-	-	-	-	A	-	-	R	R	C	4
Sandwich tern	P	-	-	-	-	-	C	-	-	-	V	U	3
Caspian tern	P	-	-	-	-	R	C	-	-	R	R	C	5
Black tern	T	-	-	-	-	U	U	-	-	U	U	A	5
Noddy tern	I	-	-	-	-	-	-	-	-	-	-	-	0
Black skimmer	P	-	-	-	-	V	C	-	-	U	V	A	5
Rock dove	P	-	-	-	-	-	-	-	C	-	-	-	1
Mourning dove	P	C	-	C	C	-	R	-	-	-	-	-	4
Ringed turtle dove	I	-	-	-	-	-	-	-	-	-	-	-	0
Ground dove	P	U	-	U	U	-	U	-	-	-	-	-	4
Mangrove cuckoo	S	-	V	-	-	-	-	-	-	-	-	-	1
Yellow-billed cuckoo	S	-	-	-	-	-	-	-	-	-	-	-	0
Black-billed cuckoo	T	-	-	-	-	-	-	-	-	-	-	-	0
Smooth-billed ani	I	-	-	-	R	-	-	-	-	-	-	-	1
Barn owl	P	V	-	V	U	V	-	-	R	-	-	-	5

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 5 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Native species (continued)													
Screech owl	P	U	-	-	-	-	-	-	-	-	-	-	1
Great horned owl	P	C	-	U	U	-	-	-	-	-	-	-	3
Burrowing owl	P	-	-	C	C	-	-	-	-	-	-	-	2
Barred owl	P	-	-	-	-	V	-	-	-	-	-	-	1
Short-eared owl	W	-	-	-	-	-	-	-	-	-	-	-	0
Chuck-will's-widow	S	C	-	-	-	-	-	-	-	-	-	-	1
Whippoorwill	W	R	-	-	-	-	-	-	-	-	-	-	1
Common nighthawk	S	A	-	C	A	-	-	-	-	-	-	-	3
Chimney swift	S	-	-	-	-	U	-	-	-	-	-	-	1
Ruby-throated hummingbird	S	-	-	-	-	-	-	-	-	-	-	-	0
Belted kingfisher	W	-	C	-	R	C	-	-	-	C	C	C	6
Common flicker	P	U	V	R	R	-	-	-	-	-	-	-	4
Pileated woodpecker	P	V	-	-	-	-	-	-	-	-	-	-	1
Red-bellied woodpecker	P	C	U	-	-	-	-	-	-	-	-	-	2
Red-headed woodpecker	P	R	-	-	R	-	-	-	-	-	-	-	2
Yellow-bellied sapsucker	W	C	V	-	-	-	-	-	-	-	-	-	2
Hairy woodpecker	P	R	-	-	-	-	-	-	-	-	-	-	1
Downy woodpecker	P	R	V	-	-	-	-	-	-	-	-	-	2
Red-cockaded woodpecker	P	R	-	-	-	-	-	-	-	-	-	-	1
Ivory-billed woodpecker	I	V	-	-	-	-	-	-	-	-	-	-	1
Eastern kingbird	S	U	-	-	R	-	-	-	-	-	-	-	2
Gray kingbird	S	-	U	-	-	-	-	-	-	-	-	-	1
Western kingbird	T	V	-	-	-	-	-	-	-	-	-	-	1
Scissor-tailed flycatcher	T	-	-	V	U	-	-	-	-	-	-	-	2
Great crested flycatcher	S	C	V	-	-	-	-	-	-	-	-	-	2
Eastern phoebe	W	U	-	-	R	R	-	-	-	-	-	-	3
Acadian flycatcher	S	-	-	-	-	-	-	-	-	-	-	-	0
Eastern wood pewee	T	U	-	-	-	-	-	-	-	-	-	-	1
Tree swallow	W	C	-	C	C	A	R	R	-	-	-	-	6
Bank swallow	T	-	-	R	U	U	-	-	-	-	-	-	3
Rough-winged swallow	T	R	-	U	U	U	-	-	-	-	-	-	4
Barn swallow	T	U	-	C	C	C	U	U	-	-	-	-	6
Cliff swallow	T	-	-	-	R	-	-	-	-	-	-	-	1

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 6 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Native species (continued)													
Purple martin	S	U	U	U	C	U	-	-	-	-	-	-	5
Blue jay	P	U	-	-	-	-	-	-	-	-	-	-	1
Scrub jay	P	-	-	-	-	-	-	-	-	-	-	-	0
Common crow	P	-	-	U	C	-	-	-	-	-	-	-	2
Fish crow	P	C	C	U	C	U	C	-	-	-	-	-	6
Carolina chickadee	P	U	-	-	-	-	-	-	-	-	-	-	1
Tufted titmouse	P	R	-	-	-	-	-	-	-	-	-	-	1
Red-breasted nuthatch	I	-	-	-	-	-	-	-	-	-	-	-	0
Brown-headed nuthatch	P	U	-	-	-	-	-	-	-	-	-	-	1
Brown creeper	I	-	-	-	-	-	-	-	-	-	-	-	0
House wren	W	C	-	-	-	-	-	-	-	-	-	-	1
Winter wren	I	-	-	-	-	-	-	-	-	-	-	-	0
Bewick's wren	I	-	-	-	-	-	-	-	-	-	-	-	0
Carolina wren	P	U	-	-	-	-	-	-	-	-	-	-	1
Long-billed marsh wren	W	-	-	-	-	-	-	-	-	-	-	-	0
Short-billed marsh wren	W	-	-	V	-	R	-	-	-	-	-	-	2
Mockingbird	P	R	-	R	R	-	-	-	-	-	-	-	3
Gray catbird	W	R	-	-	R	-	-	-	-	-	-	-	2
Brown thrasher	P	R	-	-	U	-	-	-	-	-	-	-	2
American robin	W	U	-	-	C	-	-	-	-	-	-	-	2
Hermit thrush	W	-	-	-	-	-	-	-	-	-	-	-	0
Swainson's thrush	T	-	-	-	-	-	-	-	-	-	-	-	0
Gray-cheeked thrush	T	-	-	-	-	-	-	-	-	-	-	-	0
Veery	T	-	-	-	-	-	-	-	-	-	-	-	0
Eastern bluebird	P	U	-	V	U	-	-	-	-	-	-	-	3
Blue-gray gnatcatcher	P	R	-	-	-	-	-	-	-	-	-	-	1
Golden-crowned kinglet	I	-	-	-	-	-	-	-	-	-	-	-	0
Ruby-crowned kinglet	W	R	-	-	-	-	-	-	-	-	-	-	1
Water pipit	W	-	-	-	U	R	U	V	-	-	-	-	4
Cedar waxwing	W	-	-	-	-	-	-	-	-	-	-	-	0
Loggerhead shrike	P	U	-	R	R	-	-	-	-	-	-	-	3
Starling	P	-	-	R	U	-	-	-	U	-	-	-	3
White-eyed vireo	P	R	V	-	-	-	-	-	-	-	-	-	2

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 7 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Native species (continued)													
Yellow-throated vireo	T	-	-	-	-	-	-	-	-	-	-	-	0
Solitary vireo	W	V	-	-	-	-	-	-	-	-	-	-	1
Black-wiskered vireo	W	-	U	-	-	-	-	-	-	-	-	-	1
Red-eyed vireo	S	-	-	-	-	-	-	-	-	-	-	-	0
Black-and-white warbler	W	R	U	-	-	-	-	-	-	-	-	-	2
Prothonotary warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Worm-eating warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Golden-winged warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Bachman's warbler	I	-	-	-	-	-	-	-	-	-	-	-	0
Tennessee warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Orange-crowned warbler	W	-	-	-	-	-	-	-	-	-	-	-	0
Northern parula	S	R	-	-	-	-	-	-	-	-	-	-	1
Yellow warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Magnolia warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Cape May warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Black-throated blue warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Yellow-rumped warbler	W	C	U	U	R	R	-	-	-	-	-	-	5
Black-throated green warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Cerulean warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Blackburnian warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Yellow-throated warbler	P	V	-	-	-	-	-	-	-	-	-	-	1
Blackpoll warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Pine warbler	P	C	-	-	-	-	-	-	-	-	-	-	1
Kirtland's warbler	I	V	-	-	-	-	-	-	-	-	-	-	1
Prairie warbler	W	R	-	-	-	-	-	-	-	-	-	-	1
Palm warbler	W	A	R	U	C	R	R	-	-	-	-	-	6
Ovenbird	T	R	R	-	-	-	-	-	-	-	-	-	2
Northern waterthrush	T	-	R	-	-	-	-	-	-	-	-	-	1
Louisiana waterthrush	T	-	-	-	-	-	-	-	-	-	-	-	0
Kentucky warbler	T	-	-	-	-	-	-	-	-	-	-	-	0

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 8 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Native species (continued)													
Connecticut warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Common yellowthroat	P	C	R	V	C	A	-	-	-	-	-	-	5
Yellow-breasted chat	T	-	-	-	-	-	-	-	-	-	-	-	0
Hooded warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
Canada warbler	T	-	-	-	-	-	-	-	-	-	-	-	0
American redstart	T	R	R	-	-	-	-	-	-	-	-	-	2
House sparrow	P	-	-	-	-	-	-	-	C	-	-	-	1
Bobolink	T	-	-	U	U	-	-	-	-	-	-	-	2
Eastern meadowlark	P	U	-	A	A	R	V	V	-	-	-	-	6
Red-winged blackbird	P	U	C	C	A	A	R	V	-	-	-	-	7
Orchard oriole	T	-	-	-	-	-	-	-	-	-	-	-	0
Northern oriole	T	-	-	-	-	-	-	-	-	-	-	-	0
Rusty blackbird	W	-	-	-	-	-	-	-	-	-	-	-	0
Boat-tailed grackle	P	-	R	R	C	A	U	V	-	-	-	-	6
Common grackle	P	-	-	-	R	-	-	-	-	-	-	-	1
Brown-headed cowbird	W	-	-	R	C	-	-	-	-	-	-	-	2
Western tanager	I	-	-	-	-	-	-	-	-	-	-	-	0
Scarlet tanager	T	-	-	-	-	-	-	-	-	-	-	-	0
Summer tanager	S	U	-	-	-	-	-	-	-	-	-	-	1
Cardinal	P	U	V	-	-	-	-	-	-	-	-	-	2
Rose-breasted grosbeak	T	-	-	-	-	-	-	-	-	-	-	-	0
Blue grosbeak	T	-	-	-	-	-	-	-	-	-	-	-	0
Indigo bunting	T	-	-	-	-	-	-	-	-	-	-	-	0
Painted bunting	T	-	-	-	R	-	-	-	-	-	-	-	1
Dickcissel	W	-	-	V	V	-	-	-	-	-	-	-	2
Purple finch	I	-	-	-	-	-	-	-	-	-	-	-	0
Pine siskin	I	-	-	-	-	-	-	-	-	-	-	-	0
American goldfinch	W	V	-	V	C	-	-	-	-	-	-	-	3
Rufous-sided towhee	P	C	-	R	V	V	-	-	-	-	-	-	4
Savannah sparrow	W	R	-	A	C	V	C	C	-	-	-	-	6
Grasshopper sparrow	W	V	-	U	U	-	-	-	-	-	-	-	3
Henslow's sparrow	W	-	-	-	V	-	-	-	-	-	-	-	1
LeConte's sparrow	W	-	-	-	V	-	-	-	-	-	-	-	1
Sharp-tailed sparrow	W	-	V	-	-	-	-	-	-	-	-	-	1
Vesper sparrow	W	-	-	U	U	-	-	-	-	-	-	-	2
Lark sparrow	I	-	-	-	-	-	-	-	-	-	-	-	0

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 9 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
						Native species (continued)							
Bachman's sparrow	P	U	-	-	U	-	-	-	-	-	-	-	2
Chipping sparrow	W	C	-	-	C	-	-	-	-	-	-	-	2
Field sparrow	W	-	-	-	U	-	-	-	-	-	-	-	1
White-crowned sparrow	W	-	-	-	U	-	-	-	-	-	-	-	1
White-throated sparrow	W	-	-	-	-	-	-	-	-	-	-	-	0
Fox sparrow	I	-	-	-	-	-	-	-	-	-	-	-	0
Lincoln's sparrow	T	-	-	-	-	-	-	-	-	-	-	-	0
Swamp sparrow	W	R	-	-	R	A	-	-	-	-	-	-	3
Song sparrow	W	-	-	-	V	-	-	-	-	-	-	-	1
Subtotal native species	292	81	47	50	80	93	79	15	10	47	37	62	
						Exotics or subspecies[b]							
Great white heron (subspecies)	S	-	R	-	-	V	R	-	-	-	-	-	3
Southeastern American kestrel (subspecies)	P	U	-	U	U	-	-	-	-	-	-	-	3
Florida sandhill crane (subspecies)	P	R	-	C	C	U	-	V	-	-	-	-	5
African crowned crane (introduced exotic)	I	-	-	-	-	V	-	-	-	-	-	-	1
Cuban snowy plover (subspecies)	P	-	-	-	-	-	R	-	-	-	-	-	1
Flaming parakeet (introduced exotic)	I	-	-	-	-	-	-	-	-	-	-	-	0
Mark parakeet (introduced exotic)	P	-	-	-	-	-	-	-	-	-	-	-	0
Canary-winged parakeet (introduced exotic)	I	-	-	-	-	-	-	-	-	-	-	-	0
Budgerigar (introduced exotic)	P	-	-	-	-	-	-	-	-	-	-	-	0

Note: See abbreviations and footnotes at end of table.

Table 2-17. Relative abundance of birds in habitats that occur on or near the Big Bend site[a] (Sheet 10 of 10)

Common name	Status	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Exotics or subspecies[b] (continued)													
Marian's long-billed marsh wren (subspecies)	P	-	-	-	-	-	-	-	-	-	-	-	0
Florida prairie warbler (subspecies)	P	-	C	-	-	-	-	-	-	-	-	-	1
Subtotal exotics and subspecies	11	2	2	2	2	3	2	1	0	0	0	0	
Total all species	303	83	49	52	82	96	81	16	10	47	37	62	

Abbreviations:
P = permanent resident.
S = summer resident.
W = winter resident.
T = transient.
I = irregular or accidental.
A = abundant.
C = common.
U = uncommon.
R = rare.
V = very rare.

[a] From Layne et al. (1977).
[b] Not found in the American Ornithologists' Union checklist and generally not discussed or included in discussions of native avifauna.

Table 2-18. Mammals, excluding manatees, whales, and dolphins, whose geographic ranges include the Big Bend site[a] (Sheet 1 of 2)

Common name[b,c]	Scientific name	Occurrence				
Virginia opossum	*Didelphis virginiana*	R	X	O	+	#
Short-tailed shrew	*Blarina brevicauda*	R	X	O		#
Least shrew	*Cryptotis parva*	R	X			
Eastern mole	*Scalopus aquaticus*	R		O	+	
Southeastern myotis[d]	*Myotis austroriparius*	R				
Eastern pipistrelle[d]	*Pipistrellus subflavus*	R				
Big brown bat	*Eptesicus fuscus*	R				
Seminole bat	*Lasiurus seminolus*	R				
Northern yellow bat	*Lasiurus intermedius*	R	X			
Evening bat	*Nycticeius humeralis*	R				
Rafinesque's big-eared bat[d]	*Plecotus rafinesquii*	R				
Brazilian free-tailed bat	*Tadarida brasiliensis*	R				
Nine-banded armadillo	*Dasypus novemcinctus*	R	X	O	+	#
Marsh rabbit	*Sylvilagus palustris*	R	X	O	+	#
Eastern cottontail	*Sylvilagus floridanus*	R		O	+	#
Gray squirrel	*Sciurus carolinensis*	R	X		+	#
Fox squirrel	*Sciurus niger*	R				
Southern flying squirrel	*Glaucomys volans*	R				
Southeastern pocket gopher	*Geomys pinetis*	R				
Marsh rice rat	*Oryzomys palustris*	R	X	O	+	#
Eastern harvest mouse	*Reithrodontomys humulis*	R				
Oldfield mouse[d]	*Peromyscus polionotus*	R			+	
Cotton mouse	*Peromyscus gossypinus*	R	X		+	#
Florida mouse[d]	*Peromyscus floridanus*	R				
Golden mouse[d]	*Ochrotomys nuttalli*	R				
Hispid cotton rat	*Sigmodon hispidus*	R	X	O	+	#
Eastern wood rat	*Neotoma floridana*	R			+	#
Round-tailed muskrat[d]	*Neofiber alleni*	R				
Black rat	*Rattus rattus*	R	X	O	+	#
Norway rat	*Rattus norvegicus*	R		O	+	
House mouse	*Mus musculus*	R	X	O	+	#
Nutria[d]	*Myocastor coypus*	R				
Coyote[d]	*Canis latrans*					
Red fox	*Vulpes vulpes*	R				
Gray fox	*Urocyon cinereoargenteus*	R		O		
Black bear[d,e]	*Ursus americanus*				+	
Raccoon	*Procyon lotor*	R	X	O	+	#
Long-tailed weasel	*Mustela frenata*	R				
Eastern spotted skunk	*Spilogale putorius*	R	X			#
Striped skunk	*Mephitis mephitis*	R	X			#
River otter	*Lutra canadensis*	R			+	
Mountain lion[e]	*Felis concolor*	?			+	
Bobcat	*Felis rufus*	R			+	#

Note: See abbreviations and footnotes at end of table.

Table 2-18. Mammals, excluding manatees, whales, and dolphins, whose geographic ranges include the Big Bend site[a] (Sheet 2 of 2)

Common name[b,c]		Scientific name	Occurrence				
Wild boar		*Sus scrofa*	R				
White-tailed deer		*Odocoileus virginianus*	R				
Total species	45		42	15	13	19	16
Total species on site	19						

Abbreviations:

R = reported in Hillsborough County by Layne et al. (1977).
? = occurrence questionable.
X = reported on site by Stone & Webster Engineering Corporation (1972).
O = reported on site by Long (1974a,b,c), Wunderlin and Long (1975a,b), and Wunderlin et al. (1975, 1977).
+ = reported at Beacon Key by Long (1974d,e,f and 1975).
# = Pierce (1979). Reported from Elsberry Farms, near Route 41 and Big Bend Road. Trapping records 1963 through 1970.

[a] Geographic ranges from Burt and Grossenheider (1976).

[b] Nomenclature from Jones et al. (1975).

[c] Layne et al. (1977) reported 49 species from Hillsborough County. The following species were not included in the above list, either because the records were questionable, the species was introduced, or verification was based on only a few individual specimens: southeastern shrew, red bat, black-tailed jackrabbit, and jaguarundi.

[d] Site is near the periphery of the known range of the species.

[e] Although not reported on the Beacon Key site by Long, species was reported in the area by local residents.

Table 2-19. Relative abundance of mammals for habitats that occur on or near the Big Bend site[a] (Sheet 1 of 2)

Common name	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Virginia opossum	C	U	U	U	U	U	U	U	-	-	-	8
Short-tailed shrew	R	-	-	R	R	-	-	-	-	-	-	3
Least shrew	C	-	C	C	-	-	-	-	-	-	-	3
Eastern mole	C	-	C	C	-	-	-	C	-	-	-	4
Southeastern myotis	-	-	-	-	-	-	-	C	-	-	-	1
Eastern pipistrelle	-	-	-	-	-	-	-	S	-	-	-	1
Big brown bat	-	-	-	-	-	-	-	V	-	-	-	1
Seminole bat	-	-	-	-	-	-	-	S	-	-	-	1
Northern yellow bat	A?	-	-	C	-	-	-	-	-	-	-	2
Evening bat	C	-	-	-	-	-	-	S	-	-	-	2
Rafinesque's big-eared bat	-	-	-	-	-	-	-	-	-	-	-	0
Brazilian free-tailed bat	-	-	-	-	-	-	-	C	-	-	-	1
Nine-banded armadillo	C	-	C	C	U	U	U	U	-	-	-	7
Marsh rabbit	U	-	-	U	C	-	-	-	-	-	-	3
Eastern cottontail	A	C	C	A	-	C	U	C	-	-	-	7
Gray squirrel	U	-	-	-	-	-	-	C	-	-	-	2
Fox squirrel	U	-	-	-	-	-	-	-	-	-	-	1
Southern flying squirrel	U	-	-	-	-	-	-	S	-	-	-	2
Southeastern pocket gopher	C	-	-	C	-	-	-	-	-	-	-	2
Marsh rice rat	R	C	-	C	C	-	-	-	C	-	-	5
Eastern harvest mouse	U	-	U	U	R	-	-	-	-	-	-	4
Oldfield mouse	-	-	-	C	-	-	C	-	-	-	-	2
Cotton mouse	U	R	-	-	R	R	-	-	-	-	-	4
Florida mouse	-	-	-	-	-	-	-	-	-	-	-	0
Golden mouse	-	-	-	-	-	-	-	-	-	-	-	0
Hispid cotton rat	A	U	A	A	C	U	-	-	-	-	-	6
Eastern wood rat	-	-	-	-	-	-	-	-	-	-	-	0
Round-tailed muskrat	-	-	-	S?	-	-	-	-	U	-	-	2
Black rat	C	U	-	C	-	-	-	A	-	-	-	4
Norway rat	-	-	-	-	-	-	-	U	-	-	-	1
House mouse	U	U	-	C	U	-	U	A	-	-	-	6
Nutria	-	-	-	-	-	-	-	-	A	V	-	2
Coyote	-	-	-	S	-	-	-	-	-	-	-	1
Red fox	-	-	U	C	-	-	-	U	-	-	-	3
Gray fox	U	-	-	R	-	-	-	R	-	-	-	3
Black bear	V	-	V	V	-	-	-	-	-	-	-	3
Raccoon	A	C	U	C	A	C	S	C	C	C	-	10
Long-tailed weasel	V	-	-	V	V	-	-	-	-	-	-	3
Eastern spotted skunk	U	-	C	U	-	-	-	-	-	-	-	3
Striped skunk	C	-	U	C	-	-	-	S	-	-	-	4
River otter	-	U	-	-	U	-	-	-	C	C	U	5
Mountain lion	S	-	-	S	-	-	-	-	-	-	-	2

Note: See abbreviations and footnote at end of table.

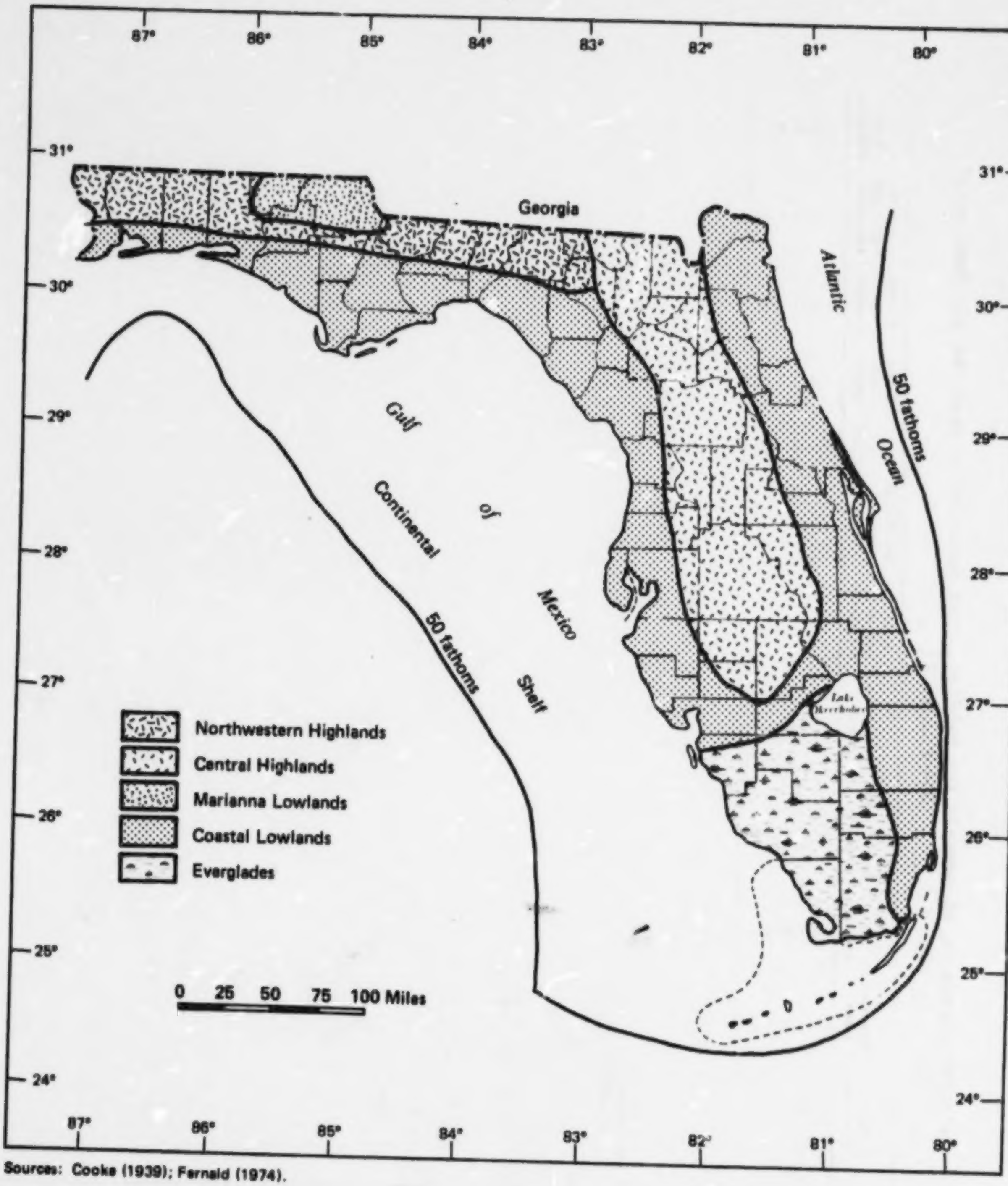
Table 2-19. Relative abundance of mammals for habitats that occur on or near the Big Bend site[a] (Sheet 2 of 2)

Common name	Typical flatwoods	Mangrove swamp	Dry prairie	Pasture and cropland	Freshwater marsh	Dunes, beaches, and flats	Artificial barren lands	Urban	Lakes and ponds	Rivers and streams	Coasts, bays, and estuaries	Total habitats
Bobcat	C	C	S	U	U	-	-	-	-	-	-	5
Manatee	-	-	-	-	-	-	-	-	-	C	C	2
Wild boar	C	-	C	C	C	-	-	-	-	-	-	4
White-tailed deer	C	-	C	C	C	-	-	-	-	-	-	4
Total species 46	29	10	15	28	15	6	6	19	5	4	2	

Abbreviations:

A = abundant.
C = common.
U = uncommon.
R = rare.
V = very rare.
S = population status questionable.
? = questionable habitat assignment.

[a] From Layne et al. (1977).


87°
86°
85°
84°
83°
82°
81°
80°
31°
30°
29°
28°
27°
26°
25°
24°
Georgia
Atlantic
Ocean
50 fathoms
Gulf
of
Mexico
Continental
Shelf
50 fathoms
Lake Okeechobee
Northwestern Highlands
Central Highlands
Marianna Lowlands
Coastal Lowlands
Everglades
0 25 50 75 100 Miles

Sources: Cooke (1939); Fernald (1974).

Figure 2-4. The Floridan Plateau.

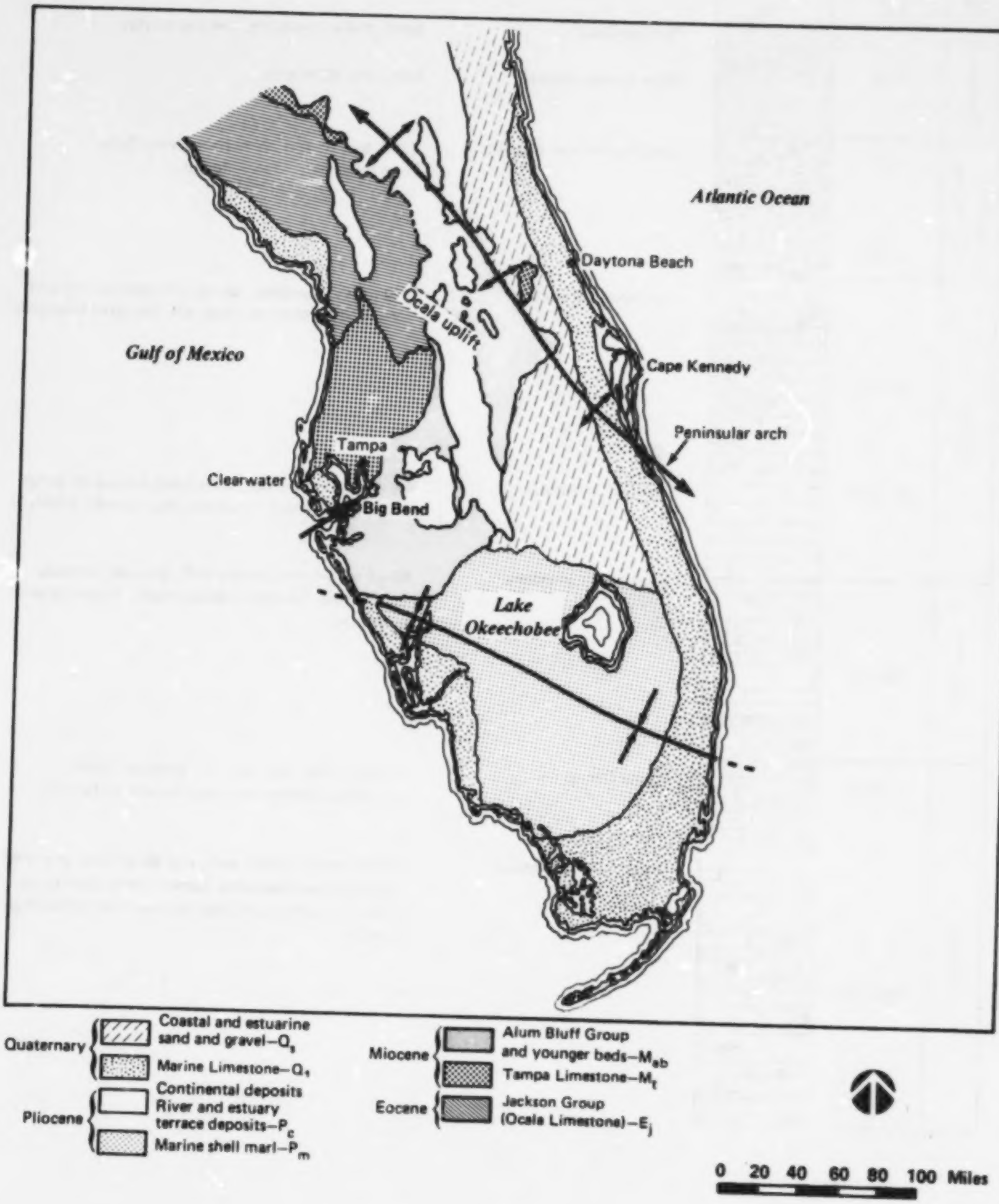
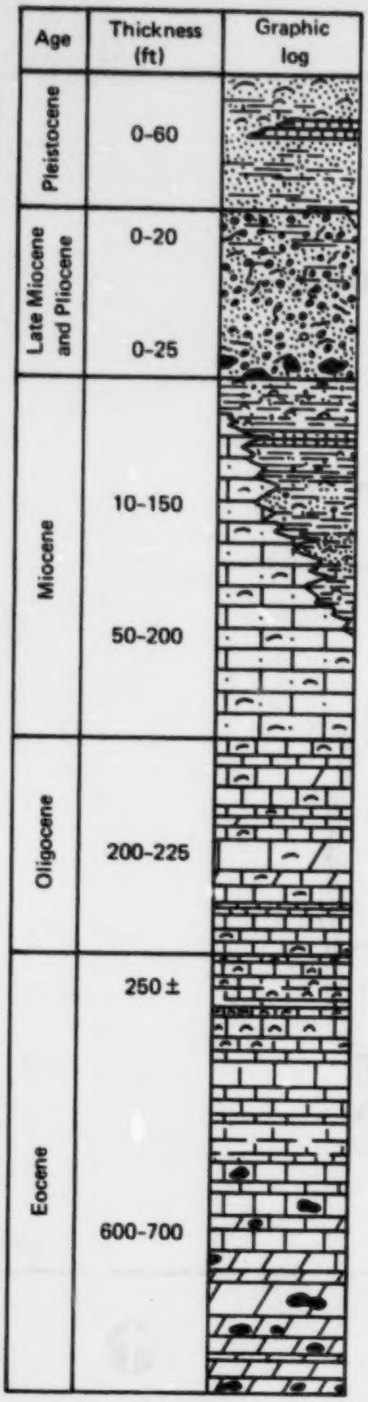
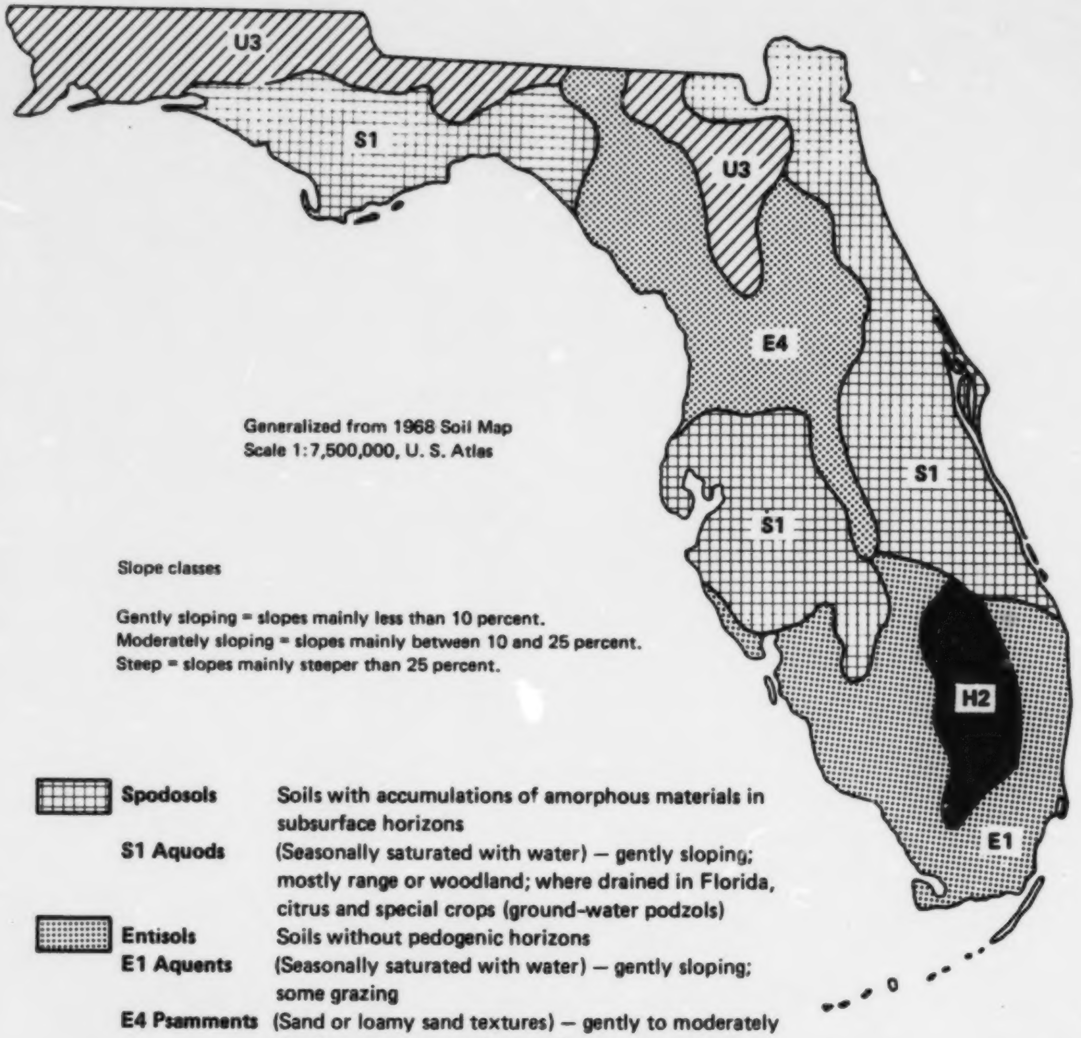

Atlantic Ocean
Daytona Beach
Ocala uplift
Gulf of Mexico
Cape Kennedy
Peninsular arch
Tampa
Clearwater
Big Bend
Lake Okeechobee
Quaternary
Coastal and estuarine sand and gravel—Q_s
Marine Limestone—Q_l
Pliocene
Continental deposits River and estuary terrace deposits—P_c
Marine shell marl—P_m
Miocene
Alum Bluff Group and younger beds—M_{ab}
Tampa Limestone—M_t
Eocene
Jackson Group (Ocala Limestone)—E_j
0 20 40 60 80 100 Miles

Figure 2-5. Regional geological map.


Age
Thickness (ft)
Graphic log
Pleistocene
0-60
Late Miocene and Pliocene
0-20
0-25
Miocene
10-150
50-200
Oligocene
200-225
Eocene
250 ±
600-700

Stratum	Description
Pamlico Sand	Sand, shells, limestone, calcareous clay
Older terrace deposits	Sand, silt, some clay
Undifferentiated deposits	Sand, quartz, and phosphate gravel; upper—bone fragments; lower—lignite
Hawthorn Formation	Green/gray, blue/gray, sandy, phosphatic clay and marl, sandy limestone, sand, silt, and shell interbeds
Tampa Formation	White to gray and tan, fairly hard, porous to dense, sandy, fossiliferous limestone, occasionally silicified
Suwannee Limestone	White to tan, moderately soft, granular, porous, fossiliferous limestone, occasionally dolomitic and crystalline
Ocala Group	White, cream, and tan, soft, granular, chalky, fossiliferous limestone, occasionally coquinoid
Avon Park Limestone	Upper—white to tan, soft, slightly chalky, granular, foraminiferal limestone, lower—tan to dark brown, hard, very porous, crystalline dolomite, occasionally lignitic

Figure 2-6. Generalized stratigraphic section.



Generalized from 1968 Soil Map
Scale 1:7,500,000, U. S. Atlas

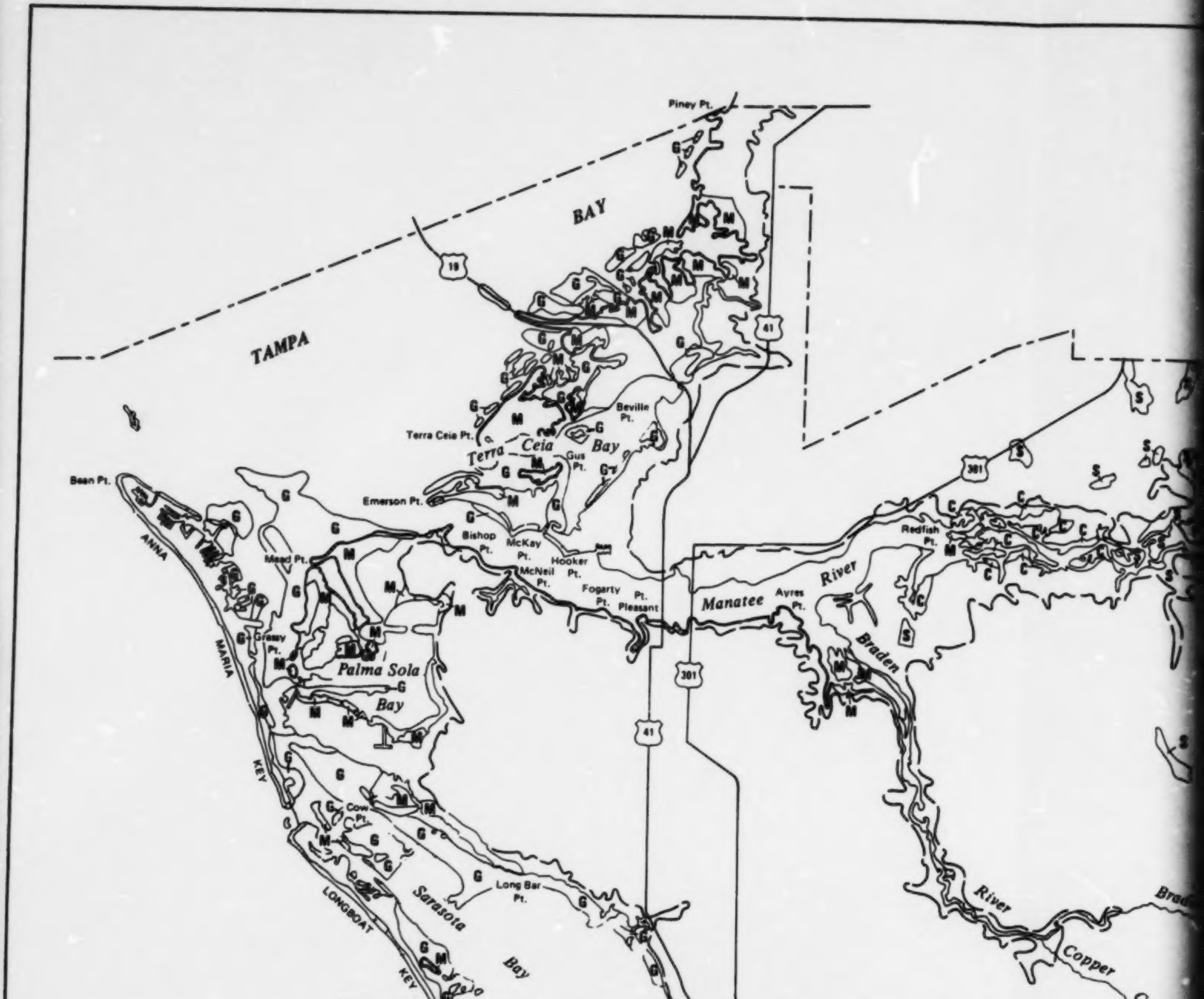
Slope classes

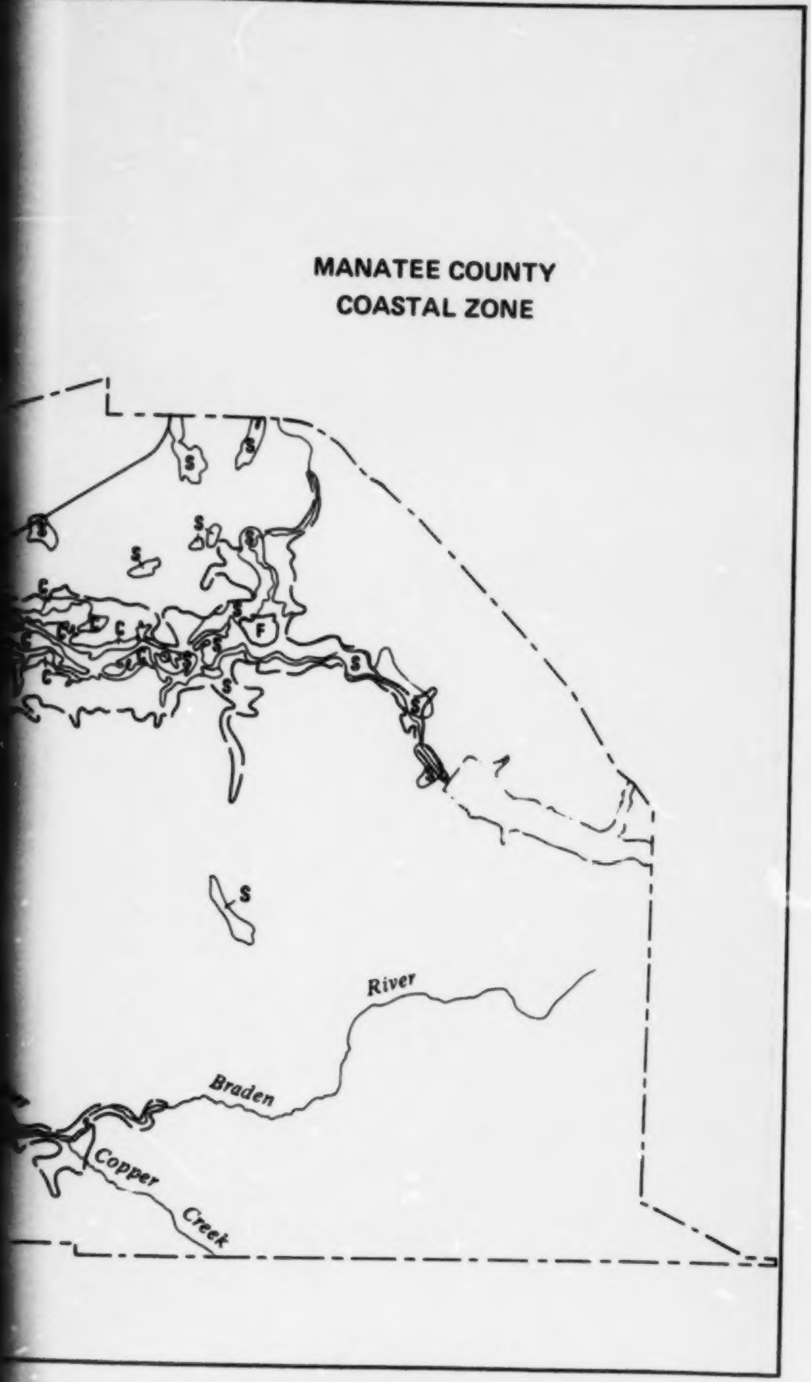
Gently sloping = slopes mainly less than 10 percent.
Moderately sloping = slopes mainly between 10 and 25 percent.
Steep = slopes mainly steeper than 25 percent.

▦	**Spodosols**	Soils with accumulations of amorphous materials in subsurface horizons
	S1 Aquods	(Seasonally saturated with water) — gently sloping; mostly range or woodland; where drained in Florida, citrus and special crops (ground-water podzols)
▒	**Entisols**	Soils without pedogenic horizons
	E1 Aquents	(Seasonally saturated with water) — gently sloping; some grazing
	E4 Psamments	(Sand or loamy sand textures) — gently to moderately sloping; mostly range in dry climates, woodland or cropland in humid climates (regosols)
■	**Histosols**	Organic soils
	H2 Saprists	(Decomposed mucks) — truck crops if drained, idle if undrained (mucks)
▨	**Ultisols**	Soils that are usually moist, with horizon of clay accumulation and a low base supply
	U3 Udults	(Low organic-matter content; temperate or warm, and moist) — gently to moderately sloping; woodland pasture, feed crops, tobacco, and cotton (red-yellow podzolic soils, some reddish-brown lateritic soils)

Source: Foth and Turk (1958).

Figure 2-7. Distribution of soil orders in Florida.


Piney Pt.
TAMPA
BAY
19
41
301
Terra Ceia Pt.
Terra Ceia Bay
Beville Pt.
Gus Pt.
Bean Pt.
Emerson Pt.
Bishop Pt.
McKay Pt.
Hooker Pt.
McNeil Pt.
Fogarty Pt.
Pt. Pleasant
Mead Pt.
Manatee River
Ayres Pt.
Redfish Pt.
Braden River
Grassy Pt.
Palma Sola Bay
ANNA MARIA KEY
Cow Pt.
Long Bar Pt.
Sarasota Bay
LONGBOAT KEY
Copper Creek
G
M
S
C


MANATEE COUNTY
COASTAL ZONE
S
S
S
S
S
C
C
C
F
S
S
S
River
Braden
Copper
Creek

G	Marine Grass Beds
C	Selected Coastal Marshes
M	Selected Coastal Mangroves
S	Selected Freshwater Swamps
F	Selected Freshwater Marshes

Note: ⁓ indicates approximate limit of 100-year hurricane flood zone.

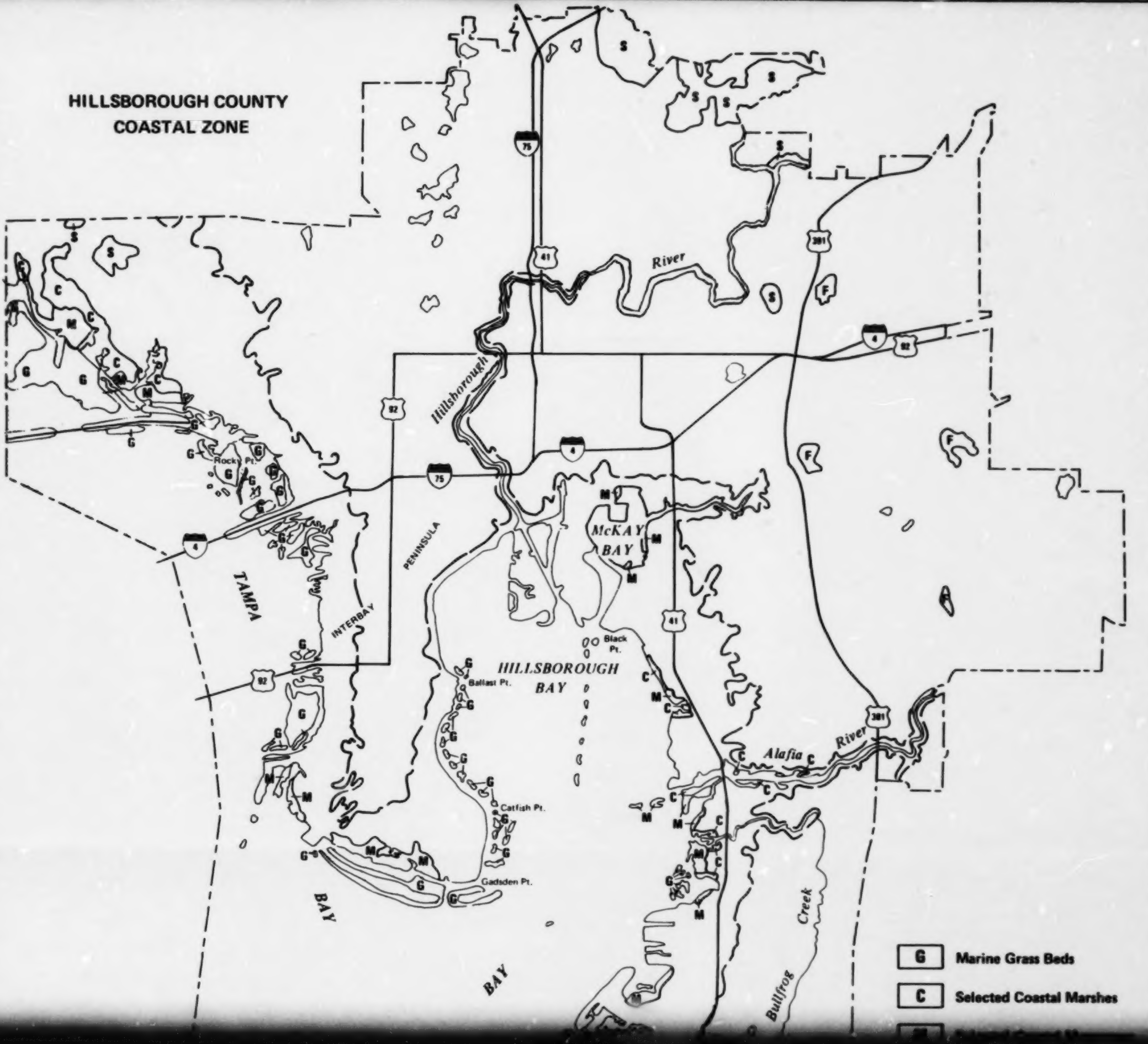
0 1 2 3 4 Miles

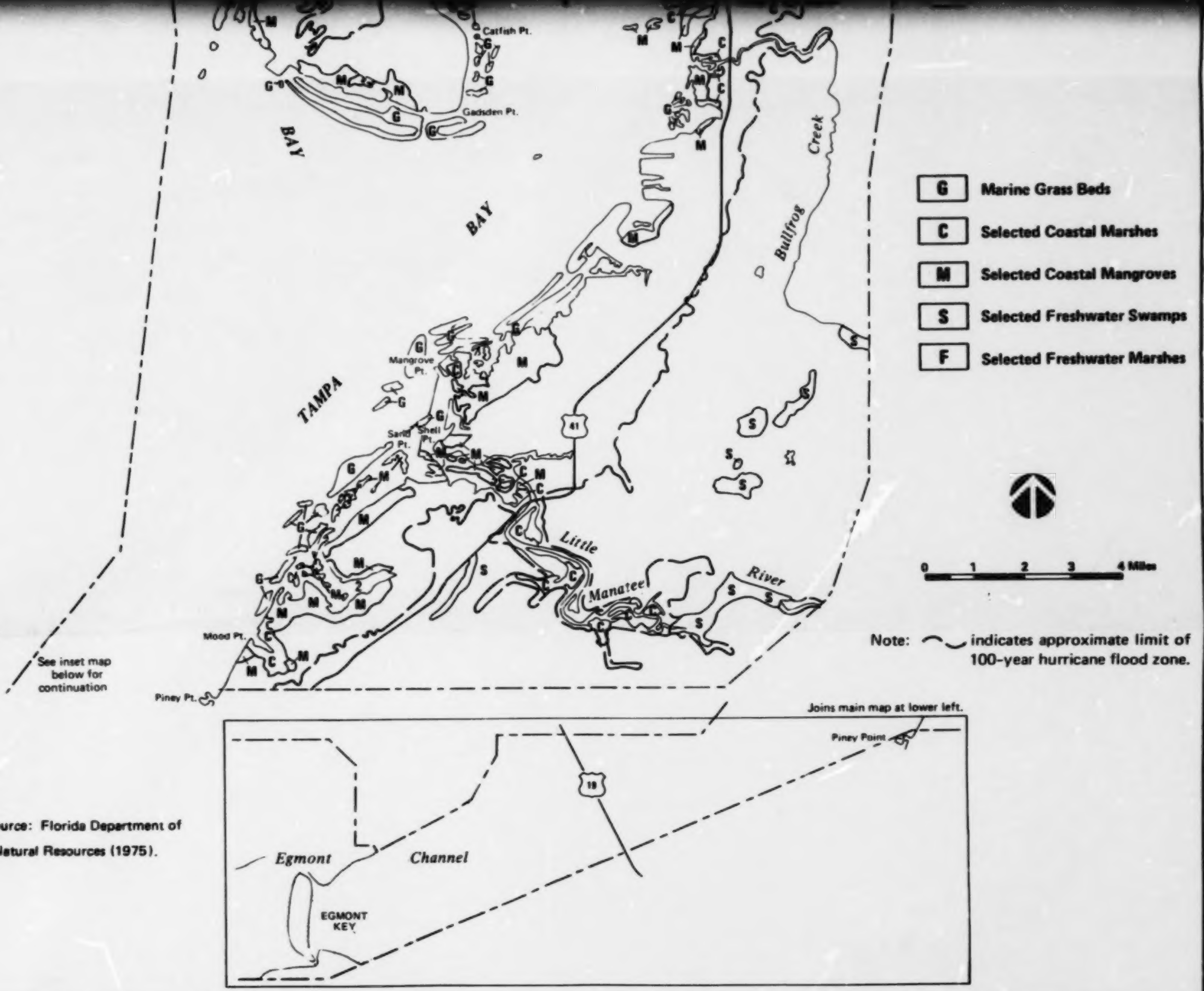
Note: Information presented is in generalized form. Local application will require mapping in greater detail.

Source: Florida Department of Natural Resources (1975a).

Figure 2-8. Distribution and areal extent of submerged and emergent vegetation in the coastal zone of the Tampa Bay System (Sheet 1 of 3).

HILLSBOROUGH COUNTY COASTAL ZONE


River
Hillsborough
McKAY BAY
HILLSBOROUGH BAY
Black Pt.
Ballast Pt.
Catfish Pt.
Gadsden Pt.
Rocky Pt.
TAMPA
BAY
INTERBAY
PENINSULA
Alafia
River
Bullfrog
Creek
75
41
4
92
301
S
F
G
C
M
G Marine Grass Beds
C Selected Coastal Marshes

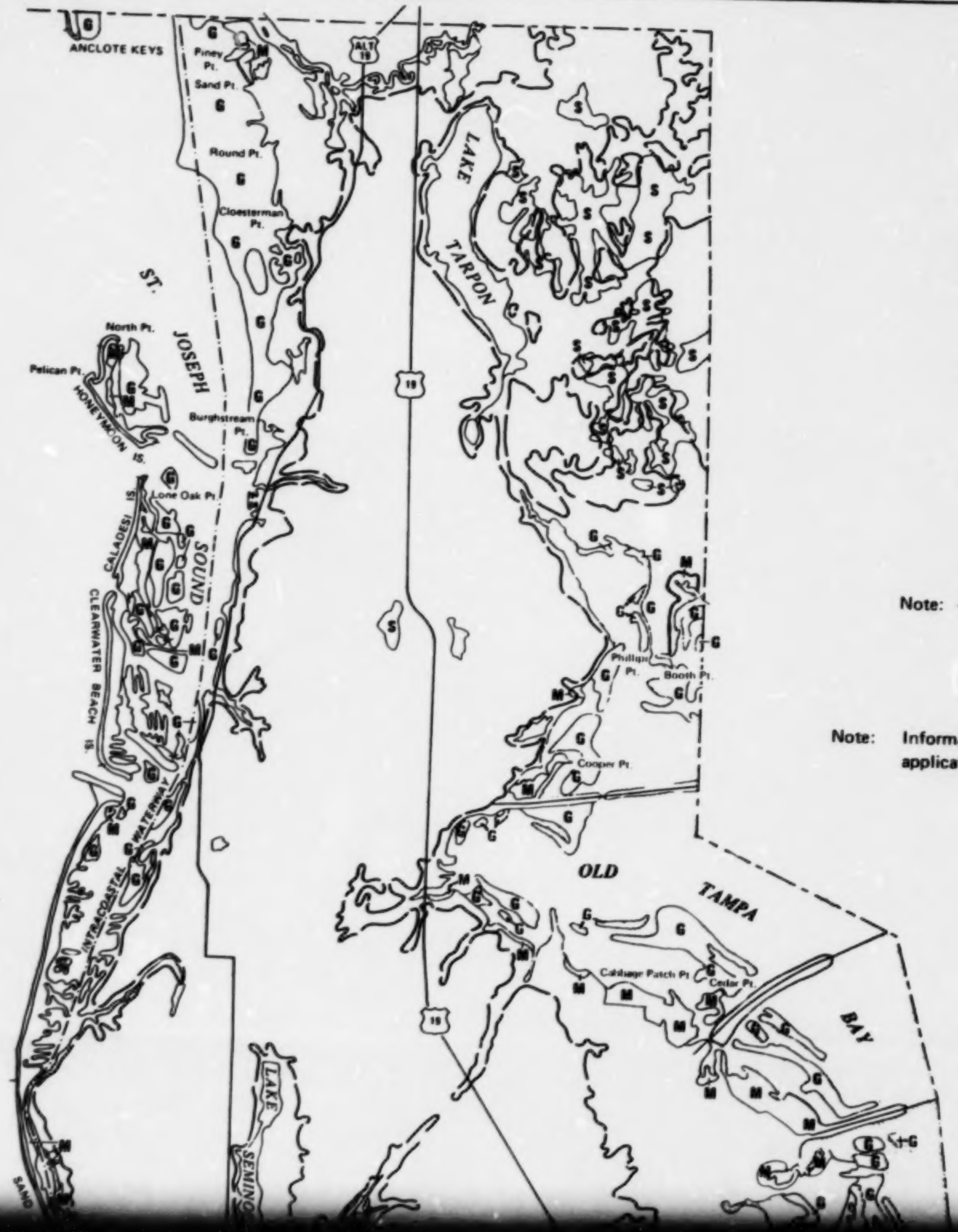

Catfish Pt.
Gadsden Pt.
BAY
TAMPA
BAY
Mangrove Pt.
Sand Pt.
Shell Pt.
Mood Pt.
Piney Pt.
Bullfrog
Creek
Little
Manatee
River
41
G
C
M
S
See inset map below for continuation
G Marine Grass Beds
C Selected Coastal Marshes
M Selected Coastal Mangroves
S Selected Freshwater Swamps
F Selected Freshwater Marshes
0
1
2
3
4 Miles
Note: ⁀‿ indicates approximate limit of 100-year hurricane flood zone.
Joins main map at lower left.
Piney Point
19
Egmont
Channel
EGMONT KEY

Source: Florida Department of Natural Resources (1975).

Note: Information presented is in generalized form. Local application will require mapping in greater detail.

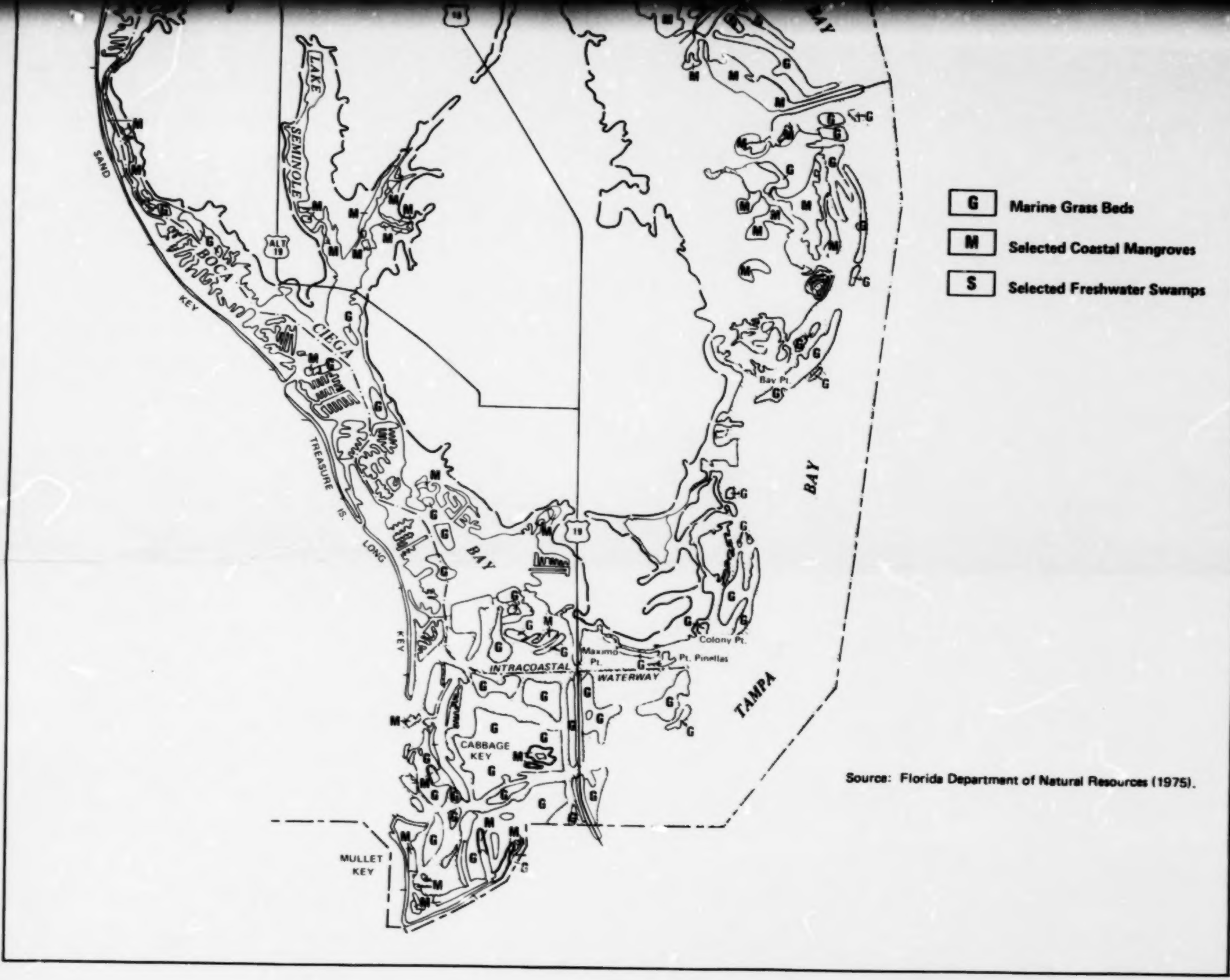
Figure 2-8. Distribution and areal extent of submerged and emergent vegetation in the coastal zone of the Tampa Bay system (Sheet 2 of 3).

PINELLAS COUNTY
COASTAL ZONE


ANCLOTE KEYS
G
Piney Pt.
Sand Pt.
Round Pt.
Cloesterman Pt.
ST. JOSEPH SOUND
North Pt.
Pelican Pt.
HONEYMOON IS.
Burghstream Pt.
Lone Oak Pt.
CALADESI IS.
CLEARWATER BEACH IS.
INTRACOASTAL WATERWAY
ALT 19
19
LAKE TARPON
S
M
Phillipi Pt.
Booth Pt.
Cooper Pt.
OLD TAMPA BAY
Cabbage Patch Pt.
Cedar Pt.
LAKE SEMINO
SAND
0 1 2 3 4 Miles

Note: ⌒ indicates approximate limit of 100-year hurricane flood zone.

Note: Information presented is in generalized form. Local application will require mapping in greater detail.


G Marine Grass Beds
M Selected Coastal Mangroves
S Selected Freshwater Swamps
SAND KEY
BOCA CIEGA BAY
LAKE SEMINOLE
ALT 19
19
TREASURE IS.
LONG KEY
Bay Pt.
BAY
TAMPA
Colony Pt.
Pt. Pinellas
Maximo Pt.
INTRACOASTAL WATERWAY
CABBAGE KEY
MULLET KEY

Source: Florida Department of Natural Resources (1975).

Figure 2-8. Distribution and areal extent of submerged and emergent vegetation in the coastal zone of the Tampa Bay system (Sheet 3 of 3).

2.3 THE WATER

2.3.1 IDENTIFICATION

2.3.1.1 Surface Water

The major surface water features around the Big Bend Station include the Tampa Bay estuarine system, the Hillsborough, Alafia, and Little Manatee Rivers, and a number of tributaries draining into the major rivers or directly into the Tampa Bay estuary. These water bodies are shown on Figure 2-9.

The Tampa Bay estuarine system, located centrally on the west coast of Florida, is composed of Tampa, Old Tampa, Hillsborough, McKay, Boca Ciega, and Terra Ceia Bays, which together make up a surface area of about 350 square miles and a total shoreline length of about 210 miles. The mean water depth is 11 feet, and 90 percent of the system is less than 22 feet deep. More information describing the hydrological characteristics of the Tampa Bay estuarine system is presented in Section 5.3.1.1.

The Hillsborough River, originating in a swampy area near Lumberton in southeastern Pasco County, flows in a general southwest direction and empties into Hillsborough Bay near Tampa. The river drains an area of about 646 square miles, which covers portions of Hillsborough, Pasco, and Polk Counties. The river flow near Tampa has been measured since October 1938 by a U.S. Geological Survey (USGS) gauging station located about 10 miles upstream from the river mouth.

The Alafia River, draining an area of about 418 square miles in eastern Hillsborough and western Polk Counties, flows through a shallow wooded valley in a well-defined channel and receives the flow of many springs. The lower reaches of the river are affected by the tides in Hillsborough Bay and, during low-flow periods, tidal fluctuation can be discerned as far as 10 miles upstream from the mouth. The Alafia River provides the major drainage for the phosphate mining areas of eastern Hillsborough and western Polk Counties.

The Little Manatee River, about 40 miles long, heads in a swampy area east of Fort Lonesome in southeastern Hillsborough County, flows westward, and empties into Tampa Bay near the town of Ruskin. The stream drains a total of about 205 square miles in southern Hillsborough County and northern Manatee County. The channel is about 100 feet above sea level at the source and is on a relatively steep gradient in the upper reaches. In its lower reaches, the river rises and falls with the tide in Tampa Bay. During low-flow periods, tidal fluctuation can be observed as far as 15 miles upstream from the mouth.

Palm River and Bullfrog Creek are two relatively small streams near the Big Bend Station area. Palm River empties into McKay Bay at Tampa and has a total drainage area of about 45 square miles. Bullfrog Creek drains 40 square miles of land and flows into Hillsborough Bay immediately south of the Alafia River outlet.

Small ditches draining coastal areas in the immediate vicinity of the Big Bend Station include Sims Branch, Jackson Branch, and Newman Branch.

2.3.1.2 Ground Water

Hillsborough County is underlain by three ground-water units; (1) the water-table aquifer, (2) the shallow artesian aquifer, and (3) the Floridan aquifer. The water-table aquifer consists of undifferentiated surficial sands and clays with a thickness ranging from a few feet to 60 feet. The shallow artesian aquifer is in the sand and limestone beds of the Hawthorn Formation, which has an average thickness on the order of 10-150 feet. The artesian Floridan aquifer is the major source of fresh ground water in the county. It consists of limestones and dolomites on the order of 1,000 feet or more in thickness. Figure 2-6 indicates, in general, that the water-table aquifer is in the strata above the Hawthorn Formation, the shallow artesian aquifer is in the Hawthorn Formation and the Floridan aquifer is in the strata below the Hawthorn Formation.

2.3.2 WATER QUANTITY

2.3.2.1 Surface Water

The average volume of water in the Tampa Bay estuarine system is estimated to be 2,110,000 acre-feet. At extreme low water level, the volume of water reduces to approximately 1,570,000 acre-feet (Tampa Electric Company 1977). The average tidal flow at the mouth of the estuary is about 900,000 cubic feet per second (cfs; Goodwin 1977). As part of the Tampa Bay estuarine system, Hillsborough Bay has about 350,000 acre-feet of water in the high-tide period and about 269,000 acre-feet at low tide (Tampa Electric Company 1977). The average tidal flow is about 90,000 cfs at the mouth of Hillsborough Bay (Goodwin 1977). More information describing various flow characteristics of the Tampa Bay estuary is presented in Section 5.3.1.1.

The Hillsborough River has an average flow of about 671 cfs. The maximum and minimum flows recorded at the USGS gauging station near Tampa were, respectively, 14,600 cfs on March 21, 1960, and zero flow from November 30 to December 2, 1945. The existing impoundment of the Hillsborough River near Tampa supports an average net diversion to consumptive use of about 35 million gallons per day (mgd). The discharge of Crystal Springs near Zephyr Hills (Pasco County) averages 39.6 mgd and probably provides almost all of the flow in the river during its low stages. In other words, during its low stages, the river serves as a convenient conduit for the transmission of spring flow to the point of use. The Hillsborough River is proposed as the primary domestic supply for the Greater Tampa Area. Domestic use in that area is expected to reach 80 mgd by 1985 and 110 mgd by the year 2000 (Tampa Bay Regional Planning Council 1970).

The USGS has several discharge gauging stations along the Alafia River. The longest gauging record is about 46 years at Lithia, Florida. This record shows an average flow of approximately 384 cfs or 240 mgd, a maximum of about 45,900 cfs on September 7, 1933, and a minimum of about 6.6 cfs on June 5, 1945. The low quartile, the flow that will be exceeded 75 percent of the time, is about 77 cfs. Development of the Alafia River as a major source of water should be based upon the creation of underground storage rather than of surface impoundment. Development of storage volumes adequate for a sustained yield equal to the difference between the average discharge and the average lower quartile discharge will provide about 220 mgd of supply for agricultural and/or industrial use (Tampa Bay Regional Planning Council 1970).

The flows of the Little Manatee River have been measured since 1939 at the USGS gauging station near Wimauma, where the drainage area is about 149 square miles. The average, maximum, and minimum flows observed are 186 cfs, 14,000 cfs, and 1.2 cfs, respectively. The almost day-by-day manner in which the upstream discharge of the river near Fort Lonesome parallels the downstream discharge near Wimauma is characteristic of a short, steep stream. There is little storage in the water course and the rate of discharge closely follows rainfall. The Little Manatee River is recommended for development as the primary source of supply for a public water system to serve the south Hillsborough area. The domestic requirements of this area will probably remain comparatively small; they are estimated at 5 mgd for 1985 and 8 mgd for the year 2000. However, a major portion of Hillsborough County's agricultural water use is concentrated in the 200-square-mile Ruskin area, which is devoted to the intensive cultivation of truck crops and of improved pasture. Some of the problems generated by heavy seasonal pumpage from the Floridan aquifer for irrigation of this area have been recognized for several years. Development of underground rather than surface storage is suggested (Tampa Bay Regional Planning Council 1970).

Crest-stage flows of Bullfrog Creek near Wimauma have been measured since 1959. No records are available for flows in the Palm River.

A hydrologic budget for Hillsborough County was computed by Menke and others (Menke, Meredith, and Wetterhall 1961). They estimated the average evapotranspiration rate to be 30 in./yr, or 60 percent of the total annual rainfall, which averages 50.24 inches in the area. They estimated average total runoff to be 15.6 in./yr in the county, or about 31 percent of total annual rainfall. Part of this amount is contributed by ground-water runoff and, therefore, approximately 6.5 in./yr., 13 percent, infiltrates into the ground-water system in Hillsborough County.

2.3.2.2 Ground Water

The water-table aquifer generally provides only a limited amount of water for domestic and irrigation needs. Water-table elevations generally coincide with ground surface elevations, particularly along the coast, and they vary with the season. The water table drops during periods of severe drought. During this time, the flow of ground water may reverse, with Tampa Bay saltwater intruding into the nearshore portion of the ground-water system. A pumping test performed in northwest Hillsborough County shows that the hydraulic conductivity of the upper sand layer is approximately 100 gallons per day (gpd) per square foot (0.01 ft/min). Hydraulic conductivity of the surficial sands calculated from grain size analyses at the site ranged from 65 to 220 gpd/ft^2 (0.015 ft/min; Sinclair 1974).

The shallow artesian aquifer in the Hawthorn Formation (10-150 feet thick), while important in Polk County, is of only minor importance throughout the small area of Hillsborough County in which it occurs (Menke, Meredith, and Wetterhall 1961). Wells yielding up to 200-500 gpm are possible within some areas.

The Floridan aquifer is the major source of fresh ground water within Hillsborough County. Most domestic and commercial wells within the area are completed in the Tampa and Suwannee Limestones, and yields up to 1,000 gpm are possible. Yields exceeding 5,000 gpm are not uncommon from wells completed in the cavernous parts of the Avon Park Formation.

The general direction of underground flow toward Tampa Bay is indicated by the slope of the piezometric surfaces of various aquifers.

2.3.3 WATER QUALITY

2.3.3.1 Chemical Description

2.3.3.1.1 pH Value*

Hillsborough Bay water is moderately buffered, with little seasonal fluctuation in pH. In most estuarine waters, the pH has a value of about 7.0 or greater because of the buffering capacity of bicarbonate, carbonate, and borate ions present in seawater. The average annual pH of the Tampa Bay estuary is about 8.0. Yearly means and ranges of pH for each subarea as recorded in 1962 are presented in Table 2-20.

Somewhat higher and lower values were listed by the Hillsborough County Environmental Protection Commission (HCEPC) in 1972. The low pH value in their data was 6.5, recorded in Hillsborough Bay, and the high was 9.5, from a station in Bishop Harbor. In natural aquatic systems, pH values tend to fluctuate somewhat and in estuarine systems these changes are generally on the order of 1 pH unit in a 24-hour period. Large fluctuations as well as persistently high or low values may be indicative of unusual natural circumstances or contamination from an outside source.

2.3.3.1.2 Dissolved Oxygen*

On a daily basis, high levels of dissolved oxygen (DO) are generally recorded during and several hours following maximum photosynthetic activity, while low DO is commonly recorded during hours of darkness and especially near dawn. Seasonally low DO may be expected during the warm-water months because of reduced O_2 solubility at those times. The depletion of oxygen in the water column usually begins in the bottom water, where microbes and products of organic decomposition create a large oxygen demand. At concentrations of 2.8 mg/ℓ and below, DO becomes a limiting factor to most aquatic vertebrates and macroinvertebrates. All minimum DO values in Table 2-20 were recorded between May and October.

An evaluation of the Hillsborough County and United States Geological Survey (USGS) data has shown that, in general, the DO level is greater than 5.0 mg/ℓ for most of the Tampa Bay area; however, in Hillsborough Bay the DO level has historically ranged between a low of 1.1 and a high of 12.0 mg/ℓ. In the Tampa Bay estuary, protracted periods of low DO have been recorded in the Hillsborough Bay subarea and in other areas where dredge-and-fill operations occur. The low DO is attributed to industrial and domestic pollution or to organic decomposition in silty sediments after dredging.

2.3.3.1.3 Biological Oxygen Demand*

Biological oxygen demand (BOD) is monitored by HCEPC. The data for 1972 are summarized as in Table 2-20. The HCEPC has reported arithmetic mean BOD_5 values as ranging from a high of 5.21 mg/ℓ at the southwest tip of Davis Island in Hillsborough Bay to a low of 1.35 mg/ℓ in the middle of Tampa Bay.

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*U.S. Army Corps of Engineers (1974a).

2.3.3.1.4 Nitrogen, Phosphorus, and Fluoride*

Detailed analysis of Hillsborough Bay has revealed that sewage treatment plants are the main source of nitrogen (N), and that the Alafia River is responsible for the majority of the phosphorus (P) concentrations. Near the mouth of Tampa Bay, N and P levels are generally 4.5 times higher than the normal value (0.03 mg/ℓ) for offshore coastal waters. Within Hillsborough Bay the levels are 10 times normal. Tidal flushing in this area is only moderate and the inflow of P is maximum; therefore, an annual buildup can be expected when annual inflow exceeds annual tidal flushing.

Changes in total Kjeldahl N and total P within the estuary over the period 1962-1972 are reflected in the Table 2-21.

Fluoride concentrations in Hillsborough Bay are generally higher than those in normal seawater, particularly at the mouth of the Alafia River. Fluoride is a byproduct of phosphate mining operations, and several mining installations are located on the Alafia River. Average fluoride concentrations for 1975 ranged from a high of 10.4 mg/ℓ near the mouth of the Alafia River to a low of 0.9 mg/ℓ near Egmont Key. The eastern portion of Hillsborough Bay averaged greater than 2.5 mg/ℓ fluoride, while the remainder of Hillsborough Bay averaged between 2.0 and 2.5 mg/ℓ (Hillsborough County Environmental Protection Commission 1975).

2.3.3.1.5 Turbidity*,†

Unpublished data by Saloman and Taylor are on file at the National Marine Fisheries Service Laboratory at Panama City, Florida. Generally, water clarity increases and turbidity decreases as one moves from the head of the estuary to its mouth. Data in Table 2-20 indicate the means and ranges of turbidity for each subarea.

A review of earlier (Taylor 1971) and more recent data (Saloman 1973a,b) by the U.S. Army Corps of Engineers indicates that, on an annual basis, average turbidity in the estuary may be expected to vary between about 4 and 10 JTU. High turbidity occurs in winter and spring when high winds periodically cause rough water and hence a resuspension of fine bottom deposits. Other causes of turbidity include the introduction of particulate and light-absorbing substances from land drainage and sewage, as well as the presence of living cells in the plankton population.

2.3.3.1.6 Water Temperature*

Considerable variations of water temperature occur throughout the Tampa Bay system. Average summer, fall, winter, and spring temperatures for the estuary are 30°, 23°, 16°, and 27°C, respectively. Annual means and ranges of water temperature for the various subareas are listed in Table 2-20.

2.3.3.1.7 Salinity*

The salinity in Tampa Bay is not widely variable. Because of the minimal freshwater inflow and large tidal exchanges of the bay and gulf water, true estuarine conditions

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*U.S. Army Corps of Engineers (1974a).
†Simon (1974).

are not maintained in Tampa Bay. Measurable salinity gradients do exist, however, and they change in character in response to seasonal runoff patterns.

Salinity values at the bay mouth seldom drop below 33 or 34 parts per thousand (ppt) because of the proximity to the gulf. The salinity gradually decreases with distance from the bay mouth with normal values of 24 to 30 ppt occurring in Old Tampa Bay. The least saline waters occur in Hillsborough Bay because of fresh water inflow from the Hillsborough, Palm, and Alafia Rivers, and from the City of Tampa sewage treatment plant.

The most recent salinity data for the estuary show that the overall annual average is about 29.5 ppt (Hillsborough County Environmental Protection Commission, unpublished). Turner and Hopkins (1974) presented seasonal averages for the entire estuary that reflect the influence of relatively high rainfall in the fall and low evaporation during winter (summer, 24.7 ppt; fall, 21.8 ppt; winter, 21.4 ppt; spring, 23.9 ppt). Yearly means and ranges of salinity for subareas of the estuary were given by Saloman and Taylor (1972) and McNulty, Lindall, and Sykes (1972). Both sets of data are presented in Table 2-22. As shown by these data, horizontal salinity gradients in the estuary are gradual, and the most brackish area is Hillsborough Bay.

Vertical salinity gradients of appreciable magnitude have been noted infrequently. The greatest known salinity difference between surface (1.4 ppt) and bottom water (20.5 ppt) was recorded in Old Tampa Bay at the eastern end of Cross Bayou Canal (Finucane and Dragovich 1966).

2.3.3.1.8 Trace Metals

The HCEPC sponsored a heavy metals survey conducted by Dr. Robert S. Braman of the University of South Florida.* Water and sediment samples were collected at nine locations in Tampa Bay from August through November 1971. Antimony, arsenic, chromium, cadmium, copper, lead, and mercury did not exceed 0.1 mg/ℓ in any of the water samples. Only zinc and iron exceeded this level in three samples. The highest level for zinc was 0.236 mg/ℓ and the highest for iron was 1.9 mg/ℓ. The HCEPC report (1972) showed the highest iron level as 0.8 mg/ℓ and highest copper level as 0.24 mg/ℓ.

Water-quality studies conducted in Tampa Bay by the U.S. Geological Survey (USGS) since 1970 have included an assay for the presence of trace metals in bay waters (Goodwin, Rosenshein, and Michaelis 1974, 1975; Goetz and Goodwin 1980). The USGS (Goetz and Goodwin 1980) has presented maps that represent "typical concentration conditions" in bay waters for total cadmium (Figure 2-10), copper (Figure 2-11), iron (Figure 2-12), lead (Figure 2-13), manganese (Figure 2-14), mercury (Figure 2-15), nickel (Figure 2-16), and zinc (Figure 2-17) from data collected at 34 stations at various intervals (shore sites: quarterly from 1972 to 1974, annually during 1975; open water sites: biannually) from June 1972 to May 1976. Data on concentrations of mean trace metals for Tampa Bay as a whole during the study period are presented in Table 2-23, in comparison with typical values for the world oceans.

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*Simon (1974).

2.3.3.2 Sewage Treatment Plants*

There are about 56 wastewater discharges into Tampa Bay. Fecal coliform counts vary throughout the region. Hillsborough Bay and Old Tampa Bay have historically had high fecal coliform counts due to the presence of numerous treatment plants in the area (See Table 2-24). For 1972, the highest count recorded (most probable number [MPN] per 100 milliliters) was 240,000 in Old Tampa Bay. Most of Hillsborough Bay had counts above 3,300 MPN per 100 milliliters, enough to limit water sports and shellfish harvesting.

With the exception of the advanced wastewater treatment facility for the City of Tampa, all sewage plants are secondary treatment systems. The largest source of wastewater is the effluent from the City of Tampa, which has a design flow of 60 million gallons per day (mgd). The treated sewage is discharged into Hillsborough Bay from the Hookers Point Treatment Plant, approximately 6 miles north of Big Bend Station. The City of Tampa recently installed this facility, replacing a 39-mgd primary treatment system.

2.3.3.3 Ground Water

Ground water in Hillsborough County occurs in a series of unconfined, semiconfined, and confined aquifers composed of undifferentiated surface sands and clays. The water table, which is supplied by local rainfall, is only a few feet below the ground surface.

Underlying the water-table aquifer is a shallow, generally artesian aquifer in the sand and limestone beds of the Hawthorn formation. The wells of this aquifer yield up to 500 gallons per minute of relatively poor quality water. The principal recharge source of this aquifer is upward leakage from the Floridan aquifer.

The Floridan aquifer is the principal source of fresh water in the state. Groundwater is usually withdrawn from the upper reaches of this aquifer. Water wells seldom reach the Avon Park formation; however, industrial users have frequently tapped this formation. Intensive pumping for agricultural and industrial uses during the last 30 years has resulted in a substantial lowering of the potentiometric surface in the densely populated coastal areas, thereby permitting local contamination by seawater.

The following are representative values of selected hydrologic parameters for the Floridan aquifer:

1. Artesian pressure varies depending on a particular location. In the immediate vicinity of Big Bend Station, the potentiometric surface varies between 0 elevation and +5 msl. At certain inland locations in the county, however, the potentiometric surface reaches a high of +100 msl.
2. Freshwater usually contains less than 500 parts per million (ppm) total dissolved solids (TDS), while the mineral concentration of brackish water (TDS) exceeds 1,000 ppm.

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*U.S. Army Corps of Engineers (1974a).

3. Aquifer coefficients are--

   a. Transmissivity (T) = 100,000 to 1,000,000 gpd/ft

   b. Storage (S) = 0.0006 to 0.002

   c. Leakance (L) = 0.005 to 0.009 gpd/$(ft^2)(ft)$

2.3.4 WATER USE

2.3.4.1 Surface Water

The major water bodies within 5 miles of the Big Bend site are the Manatee and Alafia Rivers, Hillsborough and Tampa Bays, and Bullfrog Creek. The rivers and creek provide sport fishing opportunities but have not been extensively developed for recreation. The bays offer the best opportunities for water-based recreation and are used extensively for fishing and boating. Hillsborough and Tampa Bays are also used extensively for shipping. The Port of Tampa's total annual volume, based on the most recent records, was about 41,390,000 tons, with phosphate, a major export, accounting for 44 percent of this tonnage (Tampa Port Authority 1975; Hillsborough County Board of County Commissioners 1978).

2.3.4.2 Ground Water

Communities within a 5-mile radius of the Big Bend site rely on deep wells as a potable water source. Two well fields serving water users in the area are found within the 5-mile radius. The Riverview Water Plant and Well Field, located 4.75 miles northeast of the site, is operated by Hillsborough County and serve the communities of Riverview, Gibsonton, and Gardenville, as well as the Big Bend Power Station. The Apollo Beach Well Field, two miles south-southeast, serves the Apollo Beach development. The locations of these well fields are shown in Figure 2-18. Water for irrigation in the site area is drawn from individual wells (Tampa Bay Regional Planning Council 1976).

The nearby industries and their South West Florida Water Management District (SWFWMD) permitted water withdrawals as follows:

Company	Gallons per day
Gardinier, Inc.	56,260,000
W. R. Grace & Co.	10,810,000
Brewster Phosphate	7,272,000
Borden Chemical	6,369,000
Gardinier, Inc.	5,840,700
Gardinier, Inc.	2,176,000
Agrico, Inc.	1,728,000
Gardinier-Big River, Inc.	1,627,000

In addition, there are 13 agricultural users with permitted withdrawals ranging from 1,000,000 to 3,611,000 gpd. Hillsborough County Utilities in the south county area is permitted to withdraw 13,075,000 gpd, while Big Bend Utilities is allowed to withdraw 1,850,000 gpd.

Currently, there are no known plans for future large industrial users. However, the phosphate industry in central Florida is expected to peak in the 1990s, and then begin a decline. Agricultural use is expected to remain constant or decrease. The Hillsborough County Horizon 2000 Plan (Hillsborough County Board of County Commissioners 1978) has projected that the municipal water use will increase.

2.3.5 AQUATIC FLORA

2.3.5.1 Phytoplankton

Phytoplankton studies conducted in the Tampa Bay system indicate that it is one of the most productive estuaries in the eastern Gulf of Mexico (Taylor and Saloman 1968b; McNulty 1969; McNulty et al. 1970; Steidinger 1973a, 1973b). Data compiled by Taylor and Saloman (1968b) from various studies on phytoplankton standing crop (in terms of chlorophyll a) and productivity are presented by bay area in Table 2-25. Mean chlorophyll a concentrations ranged from 3.2 to 18.9 mg/m^3; primary production values ranged from 0.27 to 0.95 g/(m^2)(d) of carbon. Gross annual phytoplankton production in the Tampa Bay system amounts to 314-427 g/m^2 of carbon (McNulty et al. 1970).

Phytoplankton standing crop and production are generally greatest in the upper reaches of the Tampa Bay estuary, gradually decreasing towards the mouth (Marshall 1956; Saunders et al. 1967; Taylor and Saloman 1968b; Turner and Hopkins 1974). Phytoplankton peaks, as measured by these parameters, generally appear in spring and summer (Kelly and Johnson 1967; McNulty 1968, 1969; McNulty et al. 1970). According to McNulty et al. (1970), the spring maximum is related to water temperature and nutrient concentrations while the summer maximum is influenced by salinity and nutrient fluctuations.

Early taxonomic studies of the phytoplankton of Tampa Bay and adjacent coastal waters were conducted by the Bureau of Commercial Fisheries and the Florida Board of Conservation as part of the investigations into the occurrence of the red tide organism, Gymnodinium breve, in Florida west coast waters (Dragovich and Kelly 1964a, 1966; Dragovich 1966; Steidinger, Davis, and Williams 1967; Saunders et al. 1967). Phytoplankton samples collected weekly and monthly at seven stations in Tampa Bay during 1963 and 1964 and examined in the live state revealed the predominance of microflagellates (less than 15 micrometers; Steidinger, Davis, and Williams 1967; Saunders et al. 1967). Diatoms were abundant from January to April and from September to October (Saunders et al. 1967). Diatoms were most numerous and fluctuations in abundance were greatest at low-salinity stations. Species diversity was greatest at stations of intermediate salinity. Two assemblages occurred in the bay system: at low to moderate salinity, Skeletonema costatum, Asterionella japonica, and Thalassiosira spp. were abundant; at high salinity, Nitzschia closterium, N. seriata, Leptocylindricus spp., Rhizosolenia spp., Chaetoceros spp., and Bellerochea malleus were numerous. Other algal taxa found to occur within the bay included members of the Cyanophyta (blue-green algae), of which Oscillatoria was the most important. Skeletonema costatum was by far the most numerous phytoplankton species in Tampa Bay and Rhizosolenia spp. and B. malleus, because of their large size, were important in terms of biomass. Studies conducted in 1963-1964 by the Bureau of Commercial Fisheries (Dragovich 1966) in Tampa Bay and adjacent coastal waters (to 20 miles offshore) also revealed the importance of S. costatum within the bay, especially from February to May. The importance of this diatom decreased with distance offshore. Other important species were A. japonica in the bay and in nearshore coastal waters, and Melosira nummuloides, Rhizosolenia stolterfothii, Biddulphia regia, B. sinensis, Coscinodiscus centralis, Coscinodiscus spp., and Chaetoceros socialis nearshore. In a later review of the diatom flora of the Gulf of Mexico, Saunders and Fryxell (1972) stated that Hemidiscus hardmanicus and Bellerochea sp. at times constitute greater than 90 percent of total phytoplankton cell surface area (a measure of biomass) in the lower bay; Tropidoneis lepidoptera is a dominant species in the middle bay while S. costatum reaches concentrations in the upper bay which are rarely exceeded anywhere.

Steidinger, Davis, and Williams (1967) identified 44 dinoflagellate taxa from collections made in Tampa Bay during 1963-1964. High variability in the weekly samples indicated that major fluctuations occurred within a few days or perhaps daily. Short-term fluctuations in phytoplankton composition, dominance, and primary production have been noted in other areas of the Gulf of Mexico (Simmons and Thomas 1962; Johansson 1975). Dragovich (1966) listed Prorocentrum micans, Prorocentrum spp., Ceratium furca, Gonyaulax spp., and Peridinium spp. as being abundant in the Tampa Bay system and in adjacent nearshore waters. Steidinger (1973a,b) lists the dinoflagellate assemblage that characterizes Tampa Bay as well as other eastern Gulf of Mexico estuaries: Ceratium hircus, Gymnodinium splendens, small Gymnodinium and Gyrodinium spp., Polykrikos spp., Peridinium spp., Gonyaulax spp., Torodinium spp., Prorocentrum micans, and P. gracile. Bloom species that occur in Tampa Bay include Gymnodinium breve, Gonyaulax monilata (both toxic species), Cochlodinium citron, Gymnodinium splendens, Gonyaulax spinifera, and Peridinium quinquecorne.

The most comprehensive phytoplankton study of the Tampa Bay system to date, in terms of number of stations sampled and range of factors assayed, was conducted by Turner and Hopkins (1974). Fifty-five stations located throughout the bay system were sampled quarterly from fall 1969 to early summer 1971 for phytoplankton, nutrients, and physical factors (Figure 2-19; Table 2-26). Annual averages of phytoplankton abundance ranged from 0.78 to 1.45×10^6 cells per liter. It was suggested that cell counts reported in the investigation were an underestimation of total phytoplankton standing crop, since athecate cells were probably destroyed by the preservation methods. Nutrient averages for the year were 2.3 µg-at./ℓ nitrate and 29.2 µg-at./ℓ phosphate, and chlorophyll (chlorophyll a + phaeopigments) concentrations averaged 16.4 mg/m^3. Thirty-nine diatom and 23 dinoflagellate taxa were recorded. The principal diatom species, in terms of numbers, was Skeletonema costatum. In terms of biomass, large diatoms such as Bellerochea malleus and Rhizosolenia stolterfothii were also important. The most numerous dinoflagellates during the period of study were Ceratium hircus and Gonyaulax balechii, both of which also contributed significantly to phytoplankton biomass. Seasonal trends for nutrients varied by area and were difficult to interpret based on quarterly surveys. Phytoplankton abundance during 1969-1970 was greatest in the fall and least in the spring in most sections of the bay. Patterns during 1970-1971 were more variable. Regionally, phytoplankton abundance and nutrient levels generally decreased with increasing salinity toward the mouth of the bay in all seasons. Low nitrogen-to-phosphorus ratios throughout the year suggested that nitrogen is more limiting than phosphorus to phytoplankton growth in Tampa Bay.

As part of the "Hourglass Cruises" conducted by the Florida Department of Natural Resources, monthly phytoplankton collections were made at three stations located on a southwesterly transect from 9 to 78 kilometers (water depth: 6, 24, and 39 meters) off Tampa Bay (Saunders and Glenn 1969; Steidinger and Williams 1970). Annual diatom densities during 1965-1966 averaged by station were 120.9, 5.6, and 0.9×10^4 cells per liter, at the 6-, 24-, and 39-meter stations, respectively. Mean cell surface area values increased with distance offshore, and species diversity was greatest at the most offshore station. Greatest diatom abundance at all three stations occurred during the period June through August. Dinoflagellate densities during 1965-1967 were highest at the most shallow station; mean densities decreased with distance offshore. Species diversity was greatest at the two stations farthest offshore.

The term "red tide" refers to the discoloration of seawater produced by blooms of toxic microorganisms that are lethal to various marine fishes, invertebrates, and sea birds. Such blooms are fairly common throughout the world and are associated with areas of upwelling or heavy land runoff. In the Gulf of Mexico, red tides are caused by dinoflagellates that produce a neurotoxin, high concentrations of which are capable of producing paralysis and mortality in a variety of fishes but in relatively few invertebrates (Steidinger 1973a,b; Steidinger, Burklew, and Ingle 1973). There are at least four toxic species in the Gulf of Mexico: Gonyaulax polyedra, G. tamarensis var. excavata, G. monilata, and Gymnodinium breve. Only the latter two have been associated with mass mortality. Gonyaulax monilata is primarily an estuarine species, while G. breve is coastal in origin. Williams and Ingle (1972) documented the distribution and known outbreaks of G. monilata in gulf waters. Such outbreaks are rare and of short duration in Florida west coast waters. However, blooms of G. breve cause extensive fish mortality (concentrations of more than 250,000 cells per liter are considered lethal to fishes) and the accumulation of toxin in some shellfish (Steidinger 1973a,b). The first written account of a red tide-associated fish kill off the Florida west coast was in 1844. Since then there have been only 30 major outbreaks (greater than one month in duration and including extensive fish kills), although the causative organism blooms annually. Generally, major red tides last only 2-4 months; however, the 1946-1947 outbreak, the most severe on record for Florida waters, continued for 11 months and affected an area from the Anclote Keys to the Florida Keys (Steidinger and Joyce 1973).

Salinity is a limiting factor in red tide dispersal; estuaries normally present a low salinity barrier to this neritic species (Steidinger and Ingle 1972). Monitoring studies have revealed that G. breve normally occurs in concentrations of less than 1,000 cells per liter, but during periods of calm weather and seas, gentle onshore winds, high levels of trace elements and growth factors, and optimum water temperature (16°-30°C) and salinity (27-37 parts per thousand [ppt]), populations have the potential to increase and accumulate in inshore waters (Steidinger 1973a,b). The rapid development of G. breve blooms (up to 75 x 10^6 cells per liter) cannot be accounted for by increased reproduction (up to one division per day); rather, it is believed that when conditions support moderate population increases, G. breve cells are physically concentrated by winds, currents, tidal action, and density gradients. Several authors (Finucane, unpubl., cited in Steidinger 1973a; Wilson 1967; Steidinger and Ingle 1972) have suggested that resident populations of G. breve exist as cysts (spores) in local sediments and that initial increases in cell concentrations in the water column are due to excystment. This speculation is supported by culture studies (Wilson 1966) as well as studies demonstrating that this type of life cycle is common with certain coastal and estuarine dinoflagellates, particularly bloom species (Wall and Dale 1968; Prakash, Medcof, and Tennant 1971; Wall 1971). Steidinger and Ingle (1972) have suggested that minor, short-lived blooms of G. breve are probably annual occurrences in various parts of the Gulf of Mexico, but that if all conditions are not simultaneously favorable, the blooms dissipate.

Commercial fishery data, while not precise, indicate no decline in catch following severe red tides (Springer and Woodburn 1960; Torpey and Ingle 1966). However, sport fisheries on inshore and offshore reefs apparently may be severely affected in localized areas (Steidinger and Joyce 1973). Steidinger and Ingle (1972) note that inshore reef fisheries were temporarily altered after the 1971 red tide in the Tampa Bay area but that repopulation through recruitment occurred within one month after the bloom terminated. However, there is evidence suggesting that it takes months or years for offshore reefs (40- to 120-foot water depth) to return to previous population levels (Steidinger 1973a,b; Smith 1976). Bottom fishes are most susceptible to red tide effects, perhaps due to size, physiology, or behavior. Oyster and clam fisheries can also be affected by red tide outbreaks. These filter-feeding organisms can temporarily accumulate G. breve cells and toxins. During red tides, shellfish beds are closed to harvesting and only reopened when shellfish meat shows no signs of toxicity.

Studies in Boca Ciega Bay have suggested that productivity of pelagic phytoplankton in inshore waters is exceeded by that of attached seagrasses, benthic and epiphytic macroscopic algae, and benthic photosynthetic microflora. Taylor and Saloman (1968b) suggested that total primary production was six times that of pelagic phytoplankton in Boca Ciega Bay. However, studies by Pomeroy (1960) indicate that in Tampa Bay waters deeper than approximately 2 meters, phytoplankton are the principal producers due to the limitation of light for benthic flora. In Hillsborough Bay, phytoplankton are apparently the only important primary producers, since a reduction of light due to increased turbidity has limited the growth of benthic seagrass to only small scattered patches (Figure 2-8; Taylor 1970).

2.3.5.2 Macrophytes

It has been estimated that benthic macrophyte coverage amounts to approximately 10 percent (21,000 acres) of the bay system Figure 2-8; (Taylor and Saloman 1966; Taylor 1971; McNulty, Lindall, and Sykes 1972; Florida Department of Natural Resources 1975b). The total area of submerged vegetation is distributed as follows: Old Tampa Bay, 6,809 acres; Hillsborough Bay, 383 acres; Tampa Bay, 7,890 acres; and Boca Ciega Bay, 5,800 acres (McNulty, Lindall, and Sykes 1972). Four species of seagrass are known to occur within Tampa Bay: Thalassia testudinum, turtle grass; Halodule (Diplanthera) wrightii, shoal grass; Syringodium filiforme, manatee grass; and Ruppia maritima, widgeon grass (Phillips 1960b, 1962, 1967; Dawes 1967, 1974; Humm 1973a). All seagrass growth occurs shoreward of the 1-fathom (mean low water) depth contour, probably due to the paucity of light in the highly turbid waters of the bay system (Phillips 1960b, 1962; Taylor and Saloman 1966). Phillips (1960b, 1962) conducted studies of the seagrasses within Tampa Bay during 1959-1960. The zonation of seagrass showed a distinct relationship with salinity and tidal level. The areal distribution and relative abundance of the four seagrass species were related to salinity conditions. In particular, the north-south distribution of Halodule and Ruppia corresponded with the observed salinity gradient in the bay. In most areas of the bay system (Old Tampa Bay, Hillsborough Bay, Tampa Bay), Halodule or Ruppia were the predominant seagrasses close to shore (approximate intertidal zone). At approximately the spring low-tide level, Syringodium was dominant. Ruppia and Halodule were often found in the Syringodium zone, but never in great abundance. Thalassia was encountered only in occasional, sparse patches. In upper Old Tampa Bay, Ruppia dominated the seagrass growth on tidal flats from the most shallow locations to the 1-fathom depth. In Boca Ciega and Terra Ceia Bays, Thalassia and Halodule were the dominant seagrasses; Thalassia predominated in open waters, while Halodule was abundant in nearshore waters of the mainland and islands.

Two areas of the Tampa Bay system have apparently undergone major reductions in seagrass growth (Figure 2-8). Phillips (1962) found that seagrasses were sparse to nonexistent in Hillsborough Bay, and that their paucity coincided with high turbidity levels. In Boca Ciega Bay, Taylor and Saloman (1968b) found major reductions in seagrass abundance to be the result of dredge-and-fill activities.

Seagrass studies of Tampa Bay suggest that optimum growth for all species occurs between water temperatures of 20° and 30°C (Phillips 1960b). Salinity ranges for optimum growth have been found to vary by species, as follows: Ruppia appears to prefer salinities of less than 25 ppt; Halodule and Syringodium apparently thrive in moderately brackish water (greater than 20 ppt), although abundant growth of Halodule is found in some areas of lower salinity; and dense Thalassia growth apparently is restricted to areas where salinity is greater than 20 ppt.

Two additional seagrass species, Halophila baillonis and H. englemanni, occur in Gulf of Mexico waters offshore of Tampa Bay, (Dawes 1967; Dawes and van Breedveld 1969). Humm (1973c) suggests that seagrasses generally do not do well in estuaries due to fluctuations in temperature, salinity, and turbidity. He postulates that more than 90 percent of the seagrass beds in the eastern Gulf of Mexico occur outside estuaries and in the open gulf.

Dawes (1974) lists 262 macroscopic algal species as occurring in the marine and brackish waters of the Florida central west coast (Table 2-27); in addition, 34 blue-green algal taxa are also listed. As the phylum Cyanophyta is presently being revised and simplified taxonomically (Drouet and Dailey 1956; Drouet 1968; Humm 1973b), the total number of blue-green algal taxa occurring in the Tampa Bay area is not precisely known. In monthly surveys conducted during 1957-1959 in Old Tampa, Tampa, and Boca Ciega bays, Phillips (1960a) collected a total of 140 algal taxa, including members of the Cyanophyta. A reduction in the number of species present occurred with distance from the bay mouth. Eighty-six taxa were collected in Old Tampa and Tampa bays, 54 of which were epiphytic. The assemblage consisted of a typical brackish water flora, the number of marine species decreasing correspondingly with salinity. In Boca Ciega Bay, 111 algal taxa were collected, 71 of which were epiphytic. The species found in this part of the bay system exemplified a transition between estuarine and marine assemblages. Unattached red algae, predominantly Hynea musciformis, Gracilaria verrucosa, and Spyridia filamentosa, and attached green algae, predominantly Enteromorpha intestinalis, and Ulva lactuca, were found in abundance in the bay system.

There were no strong seasonal patterns of species occurrence except for the tendency to lower species diversity during the summer months; a greater number of algal taxa were found during autumn, winter, or spring. Approximately 15 percent of the taxa in both the Old Tampa Bay/Tampa Bay and the Boca Ciega Bay areas were present throughout the year. A comparative study of the benthic flora of Old Tampa and Hillsborough Bays in 1968 (Federal Water Pollution Control Administration 1969), areas with similar hydrographic characteristics, revealed the presence of an algal flora of limited diversity in Hillsborough Bay, probably the result of high levels of nutrient enrichment from sewage pollution. In Old Tampa Bay, the genera Gracilaria and Ulva each comprised 9 percent of the algal standing crop. Gracilaria, which is known to proliferate under eutrophic conditions (Humm 1973b), accounted for 98 percent of the standing crop in Hillsborough Bay.

Studies by Humm and Taylor (1961) and Earle (1969) have revealed the presence of a relatively stable offshore tropical algal flora in the eastern Gulf of Mexico and have presented evidence that the Tampa Bay area marks the northern and southern limits of certain seasonal members of the Phaeophyta. During 1958-1959, Phillips and Springer (1960) collected a total of 158 algal taxa (including Cyanophyta) on the limestone reefs 9-20 miles offshore (11- to 18-meter depth) of Tampa Bay. Epiphytic algae accounted for nearly one-half of the total number of species. Approximately 60 percent of the taxa were members of the Rhodophyta. In terms of biomass, however, the contribution of these taxa was small. Macroscopic algal species found in abundance were *Sargassum filipendula*, *Halimeda scabra*, and *Rhipocephalus phoenix*. During monthly sampling in 1965-1967, Dawes and van Breedveld (1969) collected 134 algal taxa (including Cyanophyta) on a transect across the inner continental shelf in Gulf of Mexico waters (6- to 73-meter depth) offshore of Tampa Bay. At the most shallow station, there was a rather depauperate flora with pronounced seasonality in its distribution. At the deeper water stations (20-60 meters), there occurred a rich and stable algal assemblage with many perennial taxa. This distribution corresponds to the apparently greater stability of hydrographic factors (temperature, salinity, light penetration) at the deeper stations. Tropical taxa predominated in the algal collections from depths of 20-80 meters. Seasonal fluctuations were most pronounced in members of the Phaeophyta, which underwent a major growth period from late spring to summer, matured in late summer, and disappeared during early winter.

2.3.6 AQUATIC FAUNA

2.3.6.1 *Zooplankton*

Various components of the zooplankton community of the Tampa Bay system have been studied by Finucane (1966b, 1967), Eldred et al. (1965), Kelly and Dragovich (1967), Tampa Electric Company (1975), Blanchet, Avery, and Leverone (1977), Hopkins (1977), Phillips et al. (1977), and NUS Corporation (1979). The most comprehensive study to date was that conducted by Hopkins (1977) using 74-micrometer mesh nets. Surface zooplankton were collected quarterly at 42 locations in the Tampa Bay system from fall 1969 through summer 1970. The survey involved a comprehensive taxonomic analysis and quantitative estimates (numbers and biomass) of zooplankton standing crop (Tables 2-28 through 2-32). (Other aspects of the sampling program, including phytoplankton and nutrient analyses, have been discussed in Section 2.3.5; Turner and Hopkins 1974). Thirty-seven holoplankton (permanent plankton) species were identified. The most abundant species were the copepods *Oithona colcarva*, *Acartia tonsa*, and *Paracalanus crassirostris* and the appendicularian *Oikopleura dioica*, which together accounted for 60 percent and 38 percent of total zooplankton dry weight biomass and numbers, respectively. Copepod nauplii comprised 29 and 6 percent of numbers and biomass, respectively. Larvae of benthic invertebrates were a significant component of the zooplankton community, contributing, respectively, 19 and 8 percent of total numbers and biomass. The most important types were pelecypod, cirriped, polychaete, and gastropod larvae. Holoplankton diversity was greatest during the three warm-season surveys and in the most saline regions of the bay. Zooplankton standing crop was greatest in the upper bay regions and in the lower Manatee River. Seasonally, abundance and biomass were greatest during the three warm-season surveys; winter values were approximately one order of magnitude less. Zooplankton numbers and biomass over the four quarterly surveys averaged 80,782 per cubic meter and 40 mg/m^3, respectively.

During 1961-1962, Kelly and Dragovich (1967) made monthly collections of macrozooplankton at 14 stations located throughout the Tampa Bay system and in adjacent coastal waters (to 18 kilometers offshore). The large net mesh used (1.024 millimeters) was chosen primarily for collection of larval fishes and invertebrates. Macrozooplankton displacement volumes (a measure of biomass) were greatest in the summer months and least during winter. The greatest displacement volumes were consistently collected in upper Tampa Bay; somewhat smaller volumes typified nearby stations in Old Tampa Bay and at the entrance to Hillsborough Bay. The sergestid shrimp *Lucifer faxoni* and porcellanid and brachyuran crab larvae dominated the collections, accounting for, respectively, 46, 27, and 10 percent of total macrozooplankton numbers. Lucifer faxoni was most abundant in Tampa Bay, brachyuran crab larvae were most numerous in upper Tampa Bay, and larval porcellanids occurred in greatest abundance in upper Tampa Bay and at the mouth of Hillsborough Bay. The greatest densities of L. faxoni occurred in summer, fall, and winter, while larval porcellanids and brachyurans were most numerous, respectively, in spring and in summer through fall. Larval stages of fish and penaeid shrimp were also collected. Fish eggs accounted for 1 percent of the total number of organisms collected and were most abundant at the mouth of Tampa Bay. Larvae of fish and penaeid shrimp each comprised less than 1 percent of total macrozooplankton numbers. Fish larvae most commonly collected were the forage taxon, Anchoa spp. and species of commercial/sport value, Cynoscion spp., Leiostomus xanthurus, and Brevoortia spp. Other larvae of commercial/sport taxa taken in the collections included Trachinotus spp. and Soleidae. Larval and postlarval penaeid shrimp taken in the collections included Penaeus duorarum (pink shrimp), Sicyonia spp. (rock shrimp), and Trachypenaeus spp. Penaeids were taken in all seasons and at most stations; however, these forms were most abundant in the summer and were most common in lower Tampa Bay, Boca Ciega Bay, and in adjacent coastal waters. Sicyonia spp. were restricted to the offshore area and the entrance to Tampa Bay. Although specific identification of the planktonic stages of Sicyonia and Trachypenaeus spp. was not possible, several species are known to occur in the area. Sicyonia brevirostris, the largest rock shrimp and therefore commercially the most important in Florida waters (Williams 1965; Cobb, Futch, and Camp 1973), is thought to be largely confined to the middle portion of the central west Florida shelf (Cobb, Futch, and Camp 1973). Eldred (1959) and Joyce (1965) concluded that S. brevirostris was not dependent on estuarine nursery grounds during its life cycle. However, adults and subadults of this species have been taken from gulf waters 10-40 miles (6- to 21-fathom water depth) offshore of Tampa Bay (Eldred et al. 1965). Other species known to occur in the Tampa Bay area are S. typica and S. laevigata (Dragovich and Kelly 1964b; Eldred et al. 1965). Two species of Trachypenaeus, T. constrictus and T. similis, occur in the Tampa Bay area (Dragovich and Kelly 1964b; Saloman 1964; Eldred et al. 1965; Zimmerman, Feigl, and Humm 1972).

While Trachypenaeus spp. are not specifically exploited commercially, they, along with other noncommercial penaeid species, may be included in commercial catches. Eldred (1959) noted the inclusion of substantial quantities of T. similis in boxes of commercially marketed, medium-sized shrimp labelled "pink shrimp." Eldred (1959) also noted that species of Trachypenaeus are important to the fisheries of several foreign countries. Adults of these species may also occasionally be included in bait shrimp catches (Inglis and Chin 1966). The importance of the Tampa Bay estuary as a spawning and nursery habitat for fish, crabs, and shrimp that are important to Gulf of Mexico fisheries has been discussed by Sykes and Finucane (1966; Section 2.3.6.5).

It has been well documented that spawning and larval development of Penaeus duorarum, the penaeid that is important in both commercial and bait shrimp fisheries, occur in offshore waters of the Florida west coast, and that the postlarvae are recruited to estuarine nursery grounds for juvenile development (Eldred et al. 1965; Munro, Jones, and Dimitriou 1968; Jones et al. 1970; Roessler and Rehrer 1971; Florida Power Corporation 1977). Eldred et al. (1965) also collected Sicyonia spp. and Trachypenaeus spp. larvae and postlarvae from stations located at the entrance to Boca Ciega and Tampa Bays and in adjacent coastal waters. Planktonic stages of all three of these taxa were also collected during 1976 in inshore waters in the vicinity of the Anclote River just north of Tampa Bay (Florida Power Corporation 1977).

The survey by Eldred et al. (1965) suggested that none of the penaeid shrimp studied spawn in inshore waters.

In Gulf of Mexico waters offshore of Tampa Bay during 1957-1958, Eldred et al. (1961) found P. *duorarum* spawning from February to November, with a peak from April or May to September. During 1962-1963, spawning occurred from March to October (Eldred et al. 1965). Eldred et al. (1965) also found that postlarval recruitment to Tampa Bay varied from year to year. During 1962, postlarvae occurred in collections during every month but December and February, but in 1963 they were not observed from February to May. The greatest numbers of postlarvae were recruited to the Bay during July of both years. During 1961-1963, spawning of *Sicyonia* spp. occurred in waters off Tampa Bay from February or March to December. Larvae were present from March to November, with greatest densities occurring during the summer months. Postlarvae were present from May to November. The seasonal distribution of early larvae suggested that spawning of *Trachypenaeus* spp. occurred from February through November, with peaks occurring in August and September. Larvae were taken inshore primarily from March to October. Postlarvae were present inshore from April to November and were in greatest abundance from August to October.

Ichthyoplankton studies were conducted by the Bureau of Commercial Fisheries during 1963-1965 at 10 stations throughout the bay system (Finucane 1966b, 1967). Fish eggs were collected in greatest numbers at the mouth of the estuary and in adjacent coastal waters during February and in the upper reaches during May, and a second pulse occurred in both areas during June and July (Finucane 1967). Eggs were essentially absent from the bay system from October through January. Fish larvae were most abundant during June, and the most numerous taxa in various subareas of the bay included *Leiostomus xanthurus*, *Menidia beryllina*, *Cynoscion* spp., *Brevoortia* spp., and *Anchoa* spp. A comparison of collections made in Old Tampa Bay and Hillsborough Bay revealed that the greatest densities of fish eggs occurred in spring and summer and that the lowest densities occurred during winter (Finucane 1966a). Fish larvae followed a similar pattern of seasonal abundance in Old Tampa Bay, but larvae were rare in Hillsborough Bay throughout the year. Fish eggs were predominantly members of the families Engraulidae, Sciaenidae, Clupeidae, Soleidae, and Atherinidae. The occurrence of early egg stages in some of these groups indicates that some spawning occurred within the estuary.

Recently, additional studies have been conducted in two areas of the Tampa Bay system to assess the impact of power plant entrainment on planktonic stages of fish and benthic invertebrates. During 1976-1977, collections of ichthyoplankton and invertebrate macrozooplankton were made (using 363-micrometer mesh nets) at 2-week intervals in the vicinity of the Big Bend Power Plant at the mouth of Hillsborough Bay (Blanchet, Avery, and Leverone 1977; Phillips et al. 1977; Section 5.3.4). Ichthyoplankton densities in the Big Bend area were highest from March to October. Twelve families of eggs and 41 species (representing 22 families) of larvae were identified from the collections. Engraulids dominated the ichthyoplankton catches, comprising 73 percent of eggs and 87 percent of larvae. Larvae of the bay anchovy (*Anchoa mitchilli*) were most commonly collected. Sciaenids ranked second in abundance, accounting for 26 percent of eggs and 4 percent of larvae. One hundred and five invertebrate taxa were identified from the collections. However, decapod crustaceans, which accounted for 86 of the taxa, were of principal interest, since most of the other taxa were not adequately sampled using the relatively coarse mesh nets. Two peaks of abundance occurred, one in April and one in October. Larval decapods were rare during the winter months. The most abundant taxa in the collections were a pinnotherid crab (Pinnixa sayana), a porcellanid crab (Polyonyx gibbesi), and a callianasid shrimp (Upogebia affinis). Planktonic stages of commercially important taxa included larvae of the stone crab (Menippe mercenaria) and postlarvae of the pink shrimp (Penaeus duorarum).

A macrozooplankton study was also conducted from March through November 1978 in upper Old Tampa Bay in the vicinity of the A. W. Higgins Power Plant (NUS Corporation 1979). Ichthyoplankton and planktonic stages of commercially important invertebrates were collected at 2-week intervals using 505-micrometer mesh nets. A listing of taxa collected during the 9-month study as well as mean density data are presented in Table 2-33. Greatest ichthyoplankton densities occurred from April to September; eggs were most abundant during April, yolk larvae were most numerous in April, May, and July, and larvae with absorbed yolk were most abundant in May and September. Eggs and larvae of Anchoa spp. (primarily A. mitchilli) dominated ichthyoplankton catches. Other taxa of numerical importance were members of the families Gobiidae and Sciaenidae, lined sole (Achirus lineatus), and rough silverside (Membras martinica). Larvae of one commercially important squid, Lolliguncula brevis, and two crab species, Menippe mercenaria and Callinectes sapidus, and postlarvae of two penaeid shrimp, Penaeus duorarum and Trachypenaeus spp., occurred in the collections. Zoeal stages of M. mercenaria dominated the larval catches of commercially important invertebrate taxa. M. mercenaria and L. brevis larvae were present during all months of the study. Penaeus duorarum postlarvae occurred from May to November, while postlarvae of Trachypenaeus spp. occurred only in August. The megalops stage of C. sapidus was present from August to November. This late larval stage, considered the stage of greatest recruitment of this species to Florida west coast estuaries (Oesterling and Evink 1977), was also taken during meroplankton studies in the Anclote estuary (Florida Power Corporation 1977). Fish and invertebrate taxa that have been collected as planktonic stages in the Tampa Bay system are listed in Table 2-34.

2.3.6.2 Benthic Invertebrates

The first recorded observations of the benthic invertebrates of the Tampa Bay system were made by Heilprin (1887) in Boca Ciega Bay. More recently, studies by Hutton et al. (1956) and Bullock and Boss (1963) provided comprehensive taxonomic and distributional information on the benthic fauna of Boca Ciega Bay. During 1961-1962, Dragovich and Kelly (1964b) made monthly trawl and seine collections of macroinvertebrates at 42 stations located throughout the Tampa Bay system. Eighty-two species were represented in the collections (Table 2-35). The most abundant macroinvertebrates collected were tunicates of the genus Molgula, Lolliguncula brevis (brief squid), Penaeus duorarum (pink shrimp), Callinectes sapidus (blue crab), and other portunid crabs. Distributions of the 18 most numerous taxa were related to bottom type; densest aggregations occurred on sandy bottom associated with seagrass and benthic algae. Greatest species diversity was found in Tampa Bay and in the immediately adjacent Gulf of Mexico waters, and lowest diversity occurred in the upper sections of Old Tampa and Hillsborough Bays.

Beginning in 1963, collections of the benthic epifauna and infauna were made at some 400 stations located throughout the bay system by the Bureau of Commercial Fisheries (now the National Marine Fisheries Service; Taylor 1966). Based on these and some additional collections, reports have been published on the following groups: phoronids (Paine 1961; Taylor and Saloman 1970), lancelets and brachiopods (Paine 1963; Taylor and Saloman 1967, 1968a), mollusks (Taylor and Saloman 1966, 1967, 1968a, 1969, 1970; Taylor, Hall, and Saloman 1971; Sykes and Hall 1971; Hall 1972), polychaetes (Taylor and Saloman 1970; Taylor 1971), and echinoderms (Ernest 1968; Taylor and Saloman 1970). The U.S. Army Corps of Engineers (1974b) presented checklists of annelids, mollusks, and echinoderms reported from Tampa Bay (Table 2-36). Certain organisms, including phoronid, lancelet, brachiopod, polychaete, and mollusk taxa, were found to be useful as biological indicators of water quality and sediment composition. These studies have revealed that, in general, the bay system supports a rich and diverse benthic fauna. Noted exceptions are the Hillsborough Bay subarea (Taylor, Hall, and Saloman 1971; Federal Water Pollution Control Administration 1969), dredged regions of Boca Ciega Bay (Taylor and Saloman 1968b), and a system of upland canals in upper Tampa Bay (Lindall, Hall, and Saloman 1973). In these areas, natural sand bottoms have been replaced by soft, highly organic sediments and high biological oxygen demand and low dissolved oxygen levels place severe limits on the distribution, density, and abundance of bottom invertebrates (Taylor and Saloman 1968b; Taylor 1970; Table 2-37).

Studies of the benthic infauna were conducted by Taylor (1974a) for the U.S. Army Corps of Engineers at 14 transects of the ship channel from the Tampa Bay entrance to upper Hillsborough Bay. More than 300 species representing 17 major taxa were collected from the various bottom sediment types represented. Annelid worms were most numerous, accounting for 56 percent of total organisms collected. Arthropods (mostly isopods, amphipods, and cumaceans) were second in abundance (16 percent), followed by mollusks (9 percent), several minor phyla (9 percent; predominantly nematodes), chordates (7 percent; mostly lancelets), and echinoderms (2 percent; almost entirely ophiuroids). An analysis of abundance and diversity data indicated that sediment type alone did not account for distributional patterns of benthic organisms in the area of the ship channel. The grouping of abundance and diversity data by bottom type revealed that firm bottoms (a combination of sand and shell) supported the greatest number of species and individuals while channel areas supported the least. Evaluation of the proximity of the various bottom types to the ship channel suggested that tidal currents and ship traffic have an adverse effect on the stability of the benthic environment in channel areas.

Bloom, Simon, and Hunter (1972) studied the intertidal benthic infauna of three sediment types in Old Tampa Bay (clear sand, soft mud, and intermediate sandy mud). Different biotic assemblages occurred in sand and mud sediments, while a mixed assemblage was present in the intermediate substrate.

Santos (1972) and Santos and Simon (1974) studied the distribution and abundance of polychaetes associated with various intertidal grass beds in Tampa Bay. Simon and Dauer (1972a,b, 1973, 1976) and Dauer and Simon (1973, 1976a,b) followed the course of repopulation of the benthic infauna in an intertidal habitat in Tampa Bay following red tide-induced defaunation.

Taylor (1974b) compared subtidal polychaete assemblages occurring at select stations in Tampa Bay during 1963 and 1973. The greatest similarity of species assemblages between the two years was 73 percent and the lowest was 40 percent. Polychaete diversity was greater in samples collected during 1963. While the author suggested that the most plausible explanation for the lack of close similarity was the difference in sampling techniques, other possible explanations include differences in sampling period and environmental deterioration from pollution over the 10-year interval. In studies conducted in Hillsborough Bay during 1963, Taylor, Hall, and Saloman (1971) showed that the diversity and abundance of mollusks were affected by bottom conditions, and that bottom conditions were influenced by domestic and industrial pollution and dredging. On the basis of the composition, diversity, and abundance of the molluskan fauna, 42 percent of Hillsborough Bay bottom was designated unhealthy, 36 percent marginal, and 22 percent healthy (Section 5.3.4).

2.3.6.3 Fishes

Studies of the fishes of the Tampa Bay area have revealed the presence of more than 350 species (Tables 2-38 and 2-39; Springer and Woodburn 1960; Springer 1961; Moe 1963; Moe and Martin 1965; Finucane 1966b; Sykes and Finucane 1966; Humm et al. 1971; Baird et al. 1972, 1973, 1975; Powell, Dwinell, and Dwinell 1972; Smith 1976).

The inshore fish fauna in the area of Tampa Bay is basically a warm temperate assemblage (Briggs 1973). During 1957-1958, Springer and Woodburn (1960) made monthly collections at four stations located within Old Tampa, Tampa, and Boca Ciega Bays and the Cross Bayou Canal using seine, pushnet, and trawl. Collections and observations also were made within freshwater tributaries of Tampa Bay. Ninety-nine fish species were collected from within the Tampa Bay system.

Finucane (1966a) sampled 50 stations located throughout the Tampa Bay system with trawl and beach seine during the period 1961-1964. One hundred forty-seven species of fish were collected. The 15 most common fishes are listed in Table 2-40, and additional information on the seasonality of juvenile fish abundance is provided in Table 2-41. The bay anchovy (Anchoa mitchilli), and silver perch (Bairdiella chrysoura), comprised 59 percent of trawl catches, while tidewater silversides (Menidia beryllina), spot, (Leiostomus xanthurus), and pinfish (Lagodon rhomboides), accounted for 47 percent of seine catches. In addition to these species, Springer and Woodburn (1960) also noted the importance of the scaled sardine (Harengula jaguana (= H. pensacolae; Whitehead 1973)), in the Tampa Bay system. Finucane (1966a) found greatest species diversity in lower Tampa Bay and the lowest number of species in Hillsborough and Terra Ceia Bays. Comparing stations located in Old Tampa, Tampa, and Boca Ciega bays, Springer and Woodburn (1960) noted a general decrease in fish species diversity with distance from the Gulf of Mexico.

Studies conducted by Sykes and Finucane (1966) indicate that Tampa Bay serves as a nursery for at least 20 fish species of major importance to Gulf of Mexico commercial fisheries (Section 2.3.6.5). While most of these taxa were taken in all sections of the Bay, the catch was greatest in Old Tampa Bay and least in Hillsborough Bay. Considering all areas, the largest catches were taken in March and April.

Springer and Woodburn (1960) reported on red tide-induced fish kills within Tampa Bay during 1957 (Tables 2-42 and 2-43). Massive mortalities occurred from Anclote Keys to Cape Sable from late September to mid-December of that year (Steidinger and Joyce 1973). Following the red tide, there was no evidence of a lingering scarcity of those species most affected in the fish kills.

In addition to those made within Tampa Bay, Springer and Woodburn (1960) also made collections in Gulf of Mexico waters offshore of Tampa Bay. These collections were made in the course of monthly sampling at adjacent beach sites and during periodic in situ scuba observations and sampling (rotenone poisoning) of fishes inhabiting the rocky reefs located 9-20 miles offshore at water depths to 60 feet. Additional information was obtained from previous local reports of species occurrence. All of the reported occurrences are included in Table 2-39.

During 1962-1963, Moe and Martin (1965) sampled the fishes in gulf waters offshore of Tampa Bay to depths of 108 feet; most collections were made at depths of 12-33 feet. Distinct faunal differences with depth were noted; greatest numbers of fish were taken at the most inshore stations (12- to 20-foot depth). Dominant species in the collections were pinfish, pigfish (Orthopristis chrysoptera), silver perch, and leopard searobin (Prionotus scitulus); these species accounted for 68 percent of the total catch.

From 1970-1972, Smith (1976) made in situ scuba observations and collections of fishes inhabiting patch reefs 12-52 kilometers deep (13 to 40 meters) off Sarasota, to the southwest of Tampa Bay. Most observations were made at reefs 12 and 15 kilometers offshore at depths of 13-17 meters. Ninety-six fish species were recorded from all observations. Important fishes, in terms of numbers and biomass, included members of the families Serranidae, Labridae, Sciaenidae, Pomacentridae, and Pomadasyidae. Seventy-eight species that are considered characteristic of the reef habitat in gulf waters offshore of Tampa Bay (listed as primary reef fishes or known locally only from offshore reefs; Springer and Woodburn 1960; Smith 1976) are listed in Table 2-39.

A dramatic transition in the reef fish fauna was found to occur at depths between 18 and 30 meters; with increased depth, the ichthyofauna become progressively enriched with tropical species and simultaneously diminished in the diversity and abundance of temperate elements (Smith 1976). This bathymetric, zoogeographic zonation can probably be attributed to the greater stability of physical, chemical, and biological conditions in offshore waters. Although there was a slight increase in both numbers of species and individuals during the warmer months due to juvenile recruitment and the irregular occurrence of certain displaced tropical forms, the resident adult reef fishes displayed little seasonality prior to the effects of a major red tide (see below). There was little evidence of reciprocal inshore-offshore migration, but many fishes (e.g., serranids) demonstrated a body size-water depth relationship suggestive of a unidirectional ontogenetic migration.

In contrast to earlier predictions that red tide blooms would have negligible or short-lived effects on reef habitats (Springer and Woodburn 1960; Rounsefell and Nelson 1966; Steidinger and Ingle 1972), Smith (1976) documented mass mortalities of reef biota over at least 1,536 square kilometers of central west Florida shelf resulting from the 1971 red tide and subsequent stress conditions. An estimated 80-90 percent of offshore (18-30 meters) resident reef fish species perished, while at inshore (12-18 meters) reefs 77 percent of the resident reef fish species were killed. Those reef fishes which were not physiologically or behaviorally restricted to bottom waters survived in greatest numbers, possibly by moving above the thermocline into more oxygenated waters. Certain fishes colonized shallow water reefs shortly after red tide conditions abated, while others did not appear for 10-12 months afterwards. (The early arrival of certain groups of fishes can be explained by larval recruitment.) Some typically deep-water fishes recruited to shallow water reefs, possibly as a result of the elimination of ecological competitors by the red tide. Reef fish succession following the 1971 red tide was characterized by progressive species replacement.

2.3.6.4 Aquatic Mammals

Aquatic mammals which have geographic ranges that include Tampa Bay and adjacent waters of the Gulf of Mexico (Table 2-44) are the Florida or West Indian manatee (order Sirenia) and 21 species of whales and dolphins (order Cetacea). Of these

22 species, the manatee and bottle-nosed dolphin are expected to occur regularly within Tampa Bay (Sections 2.8.4.2.1.3 and 5.3.4.6).

2.3.6.5 Commercial Fisheries

During 1976, the last year for which statistics are presently available, the commercial catch of fish and invertebrates in the Gulf of Mexico amounted to 1.8 billion pounds. The dockside value of the catch was $389 million (National Marine Fisheries Service 1978). Landings on the Florida west coast comprised 6 percent (111 million pounds) of the weight and 18 percent ($70 million) of the dockside value of the total Gulf of Mexico catch (Florida Department of Natural Resources 1977). Commercial catch data for the three-county area surrounding Tampa Bay (Pinellas, Hillsborough, and Manatee Counties) are presented in Tables 2-45 through 2-47. It should be noted that these data are not necessarily a precise indication of the local catch; while the catch is calculated by landing site, some of the fish may have been taken some distance from the landing site. Moreover, the true value of a commercial catch exceeds the dockside value by at least 2-3 times because of the value added through processing, distributing, and marketing (McNulty, Lindall, and Sykes 1972).

It has been well documented that estuary-dependent species account for 90 percent or more of the total commercial catch in the Gulf of Mexico (Skud and Wilson 1960; Power 1962; Gunter 1967). Sykes and Finucane (1966) found that at least 23 important species in gulf fisheries, including the top 5 (menhaden, shrimp, crab, oysters, and mullet) inhabit the Tampa Bay system in their early developmental stages (Table 2-48).

Economically, the most important invertebrate in Tampa Bay is the pink shrimp (Higman 1955; Woodburn et al. 1957; Eldred et al. 1961; Saloman 1965, 1968; Inglis and Chin 1966; Taylor, Feigenbaum, and Stursa 1973). Juveniles of this species are taken in large numbers as bait shrimp. The Tampa Bay region is one of the leading areas of bait shrimp production in Florida (Table 2-46); landings in 1975 for the three-county area surrounding Tampa Bay amounted to more than 11 million individuals (142,000 pounds), with a dockside value of $185 thousand (Florida Department of Natural Resources 1976). Landings in the Tampa Bay area during 1976 totalled 132 thousand pounds (valued at $189 thousand), which accounted for 24 percent of the total weight of bait shrimp taken during that year in Florida west coast waters (Florida Department of Natural Resources 1977). In a study conducted in the Tampa Bay system during 1961-1962, Saloman (1965) found that the bait shrimping grounds were concentrated in lower Tampa Bay and in Boca Ciega Bay. A smaller fishery was located in Old Tampa Bay. Juvenile pink shrimp were in greatest abundance from October through February. Studies by Eldred et al. (1961) indicate that large shrimp typically migrate from Tampa Bay to offshore waters from April to July.

The adult penaeid shrimp fishery of the Gulf of Mexico is the most valuable commercial fishery in the United States (Taylor, Feigenbaum, and Stursa 1973). During 1976, 210 million pounds of shrimp were taken in Gulf of Mexico waters (National Marine Fisheries Service 1978). This represented 52 percent of the nation's total shrimp catch and had a dockside value of $275 million. Of the gulf total, 2.4 million pounds valued at $3.1 million were harvested from waters off the central west Florida coast, and almost 80 percent of these (1.9 million pounds) were landed in the counties bordering Tampa Bay (Table 2-46; Florida Department of Natural Resources 1977). Other decapod crustaceans which support valuable commercial and sport fisheries in the Tampa Bay area are the blue crab and stone crab (Table 2-46).

Mollusks of economic importance found in the Tampa Bay system include the eastern oyster (*Crassostrea virginica*), southern quahog (*Mercenaria campechiensis*), sunray venus (*Macrocallista nimbosa*) and the bay scallop (*Aequipecten irradians*); Dawson 1953; Taylor and Saloman 1966, 1968a, 1970; Sims and Stokes 1967; Stokes, Joyce, and Ingle 1968; Finucane and Campbell 1968; Godcharles 1971). While much of Tampa Bay is closed to shellfish harvesting because of pollution, oyster growers lease large acreages in Old Tampa Bay (Table 2-49; McNulty, Lindall, and Sykes 1972). The other mollusk fisheries in Tampa Bay are largely recreational because of pollution effects (Butler 1965; McNulty, Lindall, and Sykes 1972) and mismanagement (Godcharles 1971). Other mollusks found in Tampa Bay which are of potential commercial value include penshell, surf clam, crosshaired venus, coquina, whelk, and brief squid (Dragovich and Kelly 1962; Taylor and Saloman 1966, 1970; Hall 1970; Godcharles 1971).

Other invertebrates of potential value include the lugworm, (*Arenicola cristata*), which has been reared locally on an experimental basis as a bait worm (Taylor and Saloman 1968c, 1969, 1970) and the lancelet (*Branchiostoma*), which is a popular food item in Europe and Asia (Taylor and Saloman 1966, 1967, 1968a).

Aside from direct commercial value, all invertebrates in the Tampa Bay system are available at some time in their life cycle as food sources for commercially important estuarine fishes and invertebrates.

For the period 1966-1976, landings of commercially important fishes in the three-county area surrounding Tampa Bay averaged 19 percent by weight and 20 percent by dollar value of the total catch on the Florida west coast (Table 2-45; State of Florida Board of Conservation 1967, 1968, 1970; Florida Department of Natural Resources 1970 through 1977). During 1976, commercial fish landings amounted to 10.2 million pounds, with a dockside value of $3.7 million. The most valuable commercial fishes landed in the three-county area surrounding Tampa Bay are snappers, grouper, striped mullet, spotted seatrout, and mackerel (Table 2-47; Sykes and Finucane 1966; McNulty, Lindall, and Sykes 1972; Florida Department of Natural Resources, 1977). Of these, only mullet and seatrout support estuarine fisheries (Taylor, Feigenbaum, and Stursa 1973).

Sport fisheries are an important economic asset in the Tampa Bay area. It has been estimated that sport fisheries account for between one-third and one-half of the poundage reported for commercial fisheries. In addition, expenditures by sport fishermen probably equal or exceed the total value of commercial landings (Taylor, Feigenbaum, and Stursa 1973). A survey of pier fishermen conducted in Pinellas County by the National Marine Fisheries Service (cited in U.S. Army Corps of Engineers 1974b) revealed the most commonly caught fishes and seasons of greatest catch (Table 2-50). Sport fishes taken in gulf waters offshore of Tampa Bay include red and black grouper, dolphin, grunt, red snapper, Spanish and king mackerel, bluefish, cobia, sea bass, scamp, barracuda, bonito, and jacks (Moe 1963).

2.3.7 SIGNIFICANT AQUATIC HABITATS

Aquatic habitats that are considered to be of particular importance within the Tampa Bay system are the emergent stands of mangroves and tidal marshes located on the shores of the bay complex (Sections 2.2.4 and 2.8.5) and the submerged beds of benthic seagrasses (Section 2.3.5). The distribution and areal extent of these vegetation types are presented in Figure 2-8, and Table 2-51 lists the areal extent of each type by bay subarea.

Among the emergent vegetation bordering Tampa Bay, mangrove and tidal marsh assemblages are the most important. Mangroves and associated species cover approximately 17,500 acres of shoreline, while tidal marsh vegetation occupies approximately 1,700 acres (McNulty, Lindall, and Sykes 1972; Figure 2-8). Areas of the bay system containing lush stands of these assemblages are limited due to the effects of dredge-and-fill operations, draining activities for mosquito control, and seawall and causeway construction (Table 2-52).

Ecologically, mangrove stands and tidal marshes are extremely valuable biotopes. As transition zones between low-energy coastal waters and gently sloping shorelines, they serve several major functions, as summarized by McNulty, Lindall, and Sykes (1972) and Humm (1973c,d):

1. High production of organic matter. Estimates of the annual production of plant material range from nearly 4 ton/acre of dry organic matter for mangrove leaves and twigs (Heald 1969: Everglades estuary) to 10 ton/acre for Spartina (Schelske and Odum 1961; Teal 1962). These plant materials undergo decomposition and, in the form of detritus and associated microflora and microfauna, serve as the principal energy source for many detritus consumers in estuarine and coastal waters as well as a supplemental and emergency food supply for other consumers when normal food supplies become diminished. The detritus consumers, in turn, provide food for organisms at higher trophic levels (Odum 1970).
2. Land building and coastal protection. By trapping sediments and detritus, these plants tend to elevate and extend coastlines. Furthermore, their root systems and above-ground structures effectively absorb energy from waves and storm tides and offer protection from salt water intrusion and salt spray.
3. Habitats for other plants and animals. Aside from the large number of algae and some higher plants associated with mangroves and marshes, these habitats are utilized for food, cover, and reproduction by a great variety of invertebrates and fishes, including those of commercial value, as well as a number of reptiles, birds, and mammals.

It has been estimated that benthic seagrasses and associated macroalgae cover approximately 21,000 acres of Tampa Bay submerged bottom (McNulty, Lindall, and Sykes 1972; Figure 2-8). Seagrasses serve ecological functions similar to emergent aquatic plants (Humm 1973a):

1. They serve as a sediment trap and stabilize the bottom sediments.
2. They carry on basic productivity that may exceed that of the benthic and planktonic algae. Jones (1968) has determined that well-developed beds of turtle grass (Thalassia testudinum) fix about 900 $g/(m^2)(yr)$ of carbon.
3. They serve as a direct food source for a few herbivores (i.e., sea urchins, certain fish, sea turtles, and manatees) and as an indirect food source in the form of detritus for many other invertebrates and fishes.
4. They provide a habitat and refuge for numerous organisms, including those of commercial value such as scallops, shrimp, crabs, and many fish.
5. They serve as an important substrate for many species of invertebrates and benthic algae (Humm 1964; Ballantine 1972).

Table 2-20. Annual means and ranges of selected chemical parameters for subareas of the Tampa Bay estuary, 1962

	pH[a] (pH units)		Dissolved oxygen[b] (mg/ℓ)		BOD[b] (mg/ℓ)		Turbidity[a] (JTU)		Water temperature[b] (°C)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Old Tampa Bay	7.9	6.7-8.4	6.3	2.7-10.6	2.3	2.0- 5.0	7.4	1.4-26.0	22.6	10.8-32.6
Hillsborough Bay	7.9	7.2-8.6	6.4	0.9-11.6	3.1	0.8-22.0	13.7	1.7-74.0	23.2	11.2-35.1
Upper Tampa Bay	8.0	7.3-8.4	5.8	1.1- 8.1	1.7	0.4- 8.5	7.9	1.0-64.0	22.6	11.8-32.0
Lower Tampa Bay	8.1	7.6-8.4	5.7	1.4- 8.5	1.7	0.4- 4.0	10.6	2.1-82.0	21.5	8.8-32.0
Boca Ciega Bay	8.1	7.7-8.5	5.4	1.6-10.6	1.7	0.4- 4.0	7.7	2.9-21.5	22.5	11.2-31.6
Terra Ceia Bay	7.9	7.6-8.2	5.1	2.1- 7.4	1.7	0.4- 4.0	9.8	2.0-68.0	21.8	12.5-29.6

Abbreviations:
BOD = biological oxygen demand.
JTU = Jackson turbidity units.

[a] Saloman and Taylor (1972).
[b] U.S. Army Corps of Engineers (1974a).

Table 2-21. Total Kjeldahl nitrogen and total phosphorus in subareas of the Tampa Bay estuary

Subarea	1962		1972	
	N (mg/ℓ)	P (mg/ℓ)	N (mg/ℓ)	P (mg/ℓ)
Old Tampa Bay	45.0	23.1	32.1	35.5
Hillsborough Bay	56.6	25.9	37.7	71.0
Upper Tampa Bay	37.2	23.4	23.6	38.7
Lower Tampa Bay	32.0	8.6	14.3	11.9
Boca Ciega Bay	34.2	7.0	ND	ND
Terra Ceia Bay	ND	ND	ND	ND

Table 2-22. Annual means and ranges of salinity in subareas of the Tampa Bay estuary[a]

Subarea	Mean (ppt)	Range (ppt)
Old Tampa Bay (S&T)	22.5	14.9 to 27.7
Upper Old Tampa Bay	21.8	0.9 to 30.3
Mid-Old Tampa Bay	23.3	5.3 to 30.3
Lower Old Tampa Bay	25.3	19.6 to 29.7
Hillsborough Bay (S&T)	20.9	9.6 to 25.3
Upper Hillsborough Bay	20.8	7.4 to 28.5
Lower Hillsborough Bay	22.8	13.5 to 31.9
Upper Tampa Bay (S&T)	24.4	19.0 to 28.9
Lower Tampa Bay (S&T)	30.1	22.4 to 35.6
Upper Tampa Bay	24.4	14.0 to 30.8
Mid-Tampa Bay	26.5	14.3 to 32.5
Lower Tampa Bay	30.4	21.9 to 35.0
Tampa Bay entrance	32.2	21.1 to 36.8
Boca Ciega Bay (S&T)	31.2	14.5 to 35.0
Boca Ciega Bay	32.6	22.7 to 37.3
Terra Ceia Bay (S&T)	27.3	15.8 to 31.5
Terra Ceia Bay	24.5	1.0 to 33.7
Offshore	34.1	22.6 to 39.0

Abbreviations:
ppt = parts per thousand.
S&T = Saloman & Taylor.

[a] From Saloman and Taylor (1972) and McNulty, Lindall, and Sykes (1972).

Table 2-23. Average concentration of selected trace metals in Tampa Bay and in ocean water[a]

Element	Concentration in Tampa Bay (μg/ℓ)[b]		Concentration in ocean water (μg/ℓ, dissolved)[c]
	Dissolved	Total or total recoverable	
Cadmium[d]	0.5 (4)[f,g]	2 (103)[f]	0.1
Copper[e]	5 (37)[f,g]	20 (147)[f]	3
Iron[e]	80 (38)	240 (149)	3
Lead[d]	1 (36)[f]	8 (135)	0.03
Manganese[e]	30 (37)[f]	50 (132)	2
Mercury	0.0 (36)[f]	0.3 (135)[f]	0.2
Nickel[d]	1 (5)[f]	3 (46)[f]	7
Zinc[e]	30 (36)[f]	60 (148)[f]	10

[a] Adapted from Goetz and Goodwin (1980).

[b] Number of observations in parentheses.

[c] Data from National Academy of Sciences (1971).

[d] Element is measured to the nearest μg/ℓ.

[e] Element is measured to the nearest 10 μg/ℓ.

[f] Mean is near the detection limit for the method used.

[g] Mean is reported to greater accuracy than individual measurements to indicate a nonzero mean.

Table 2-24. Major wastewater sources affecting Tampa and Hillsborough Bays[a] (Sheet 1 of 2)

Discharge source/affected area	Design discharge (mgd)
St. Petersburg area	
Fort DeSoto Park/East Beach	0.012
Fort DeSoto Park/Fort Area	0.012
Fort DeSoto Park/North Beach	0.003
Madelaine Key/Boca Ciega Bay	0.08
Terra Verde Subdivision/Boca Ciega Bay	0.05
St. Petersburg (city-southwest plant)/Tampa Bay	6.0
St. Petersburg (city-Albert Whitted plant)/Tampa Bay	11.7
St. Petersburg (city-northeast plant)/Tampa Bay	5.33
Old Tampa Bay area	
Largo Plant/Old Tampa Bay	3.0
Clearwater (city-east plant)/Old Tampa Bay	3.2
Safety Harbor (city)/Old Tampa Bay	0.192
Oldsmar (city)/Old Tampa Bay	0.12
Double Branch Ranch Trailer Park/Old Tampa Bay	0.004
Tampa Shores (Tampa Shores Utility Corp.)/Old Tampa Bay	0.4
Colonial Coach Estates Mobile Home Park/Old Tampa Bay	0.055
River Oaks (Hillsborough County)/Old Tampa Bay	0.525
Baycrest Plaza (Baycrest Utility Corp.)/Old Tampa Bay	0.296
Sweetwater Utilities #2/Old Tampa Bay	0.91
Citrus Park Laundry/Old Tampa Bay	0.02
Sweetwater Utilities #1/Old Tampa Bay	0.453
Egypt Shrine Temple/Old Tampa Bay	0.003
Tampa Suburban Utilities/Old Tampa Bay	0.075
Pinecrest Utility Corporation/Old Tampa Bay	0.525
Sun Lake Park/Old Tampa Bay	0.035
Carrollwood Subdivision (Florida Cities Water Company)/ Old Tampa Bay	0.453
Honeywell Plant #2/Old Tampa Bay	0.1
National Gypsum/Old Tampa Bay	0.0075
Hillsborough Bay area	
MacDill Air Force Base/Hillsborough Bay	0.67
Tampa Yacht Club/Hillsborough Bay	0.005
Hookers Point (City of Tampa)/Hillsborough Bay	60.0
Seabreeze Restaurant/Hillsborough Bay	0.005
Tampa Electric Company-Gannon Station/Hillsborough Bay	0.004
Hazzard Mobile Home Park/Hillsborough Bay	0.004
Central Realty Company/Hillsborough Bay	0.009
Williams Truck Stop/McKay Bay	0.012
Florida Steel Corporation/McKay Bay	0.01

Note: See abbreviation and footnote at end of table.

Table 2-24. Major wastewater sources affecting Tampa and Hillsborough Bays (Sheet 2 of 2)

Discharge source/affected area	Design discharge (mgd)
Hillsborough Bay area (continued)	
Adamo Acres Subdivision (Hillsborough Utilities Company)/Hillsborough Bay	0.272
Clair Mel City (Seaboard Utilities)/Hillsborough Bay	0.82
Nitram Chemicals/Hillsborough Bay	0.005
Lykes Brothers Meat Packers/Hillsborough Bay	0.347
GAF Corporation/Hillsborough Bay	0.003
Starkey's Trailer Park/Hillsborough Bay	0.005
Progress Village (Southeastern Utilities)/ Hillsborough Bay	0.25
Riverview Laundry/Hillsborough Bay	0.02
Gardinier, Inc. (Cities Service)/Hillsborough Bay	0.1
Harnell Laundry/Hillsborough Bay	0.02
Nistal Trailer Park/Hillsborough Bay	0.005
Alafia Mobile Home Park/Hillsborough Bay	0.02
Eastwood Estates Mobile Home Park/Hillsborough Bay	0.03
Tampa Electric Company-Big Bend/Hillsborough Bay	0.004
Southern Hillsborough and Manatee County area	
Ruskin Tomato Growers/Tampa Bay	0.006
Ruskin Vegetable Growers/Tampa Bay	0.006
Apollo Beach (Big Bend Utilities Subdivision)/ Tampa Bay	0.5
Bahia Beach/Tampa Bay	0.035
Coffee Cup Restaurant/Tampa Bay	0.003
Ruskin Laundry/Tampa Bay	0.02
Total	96.75

Abbreviation: mgd = million gallons per day.

[a] Adapted from Hillsborough County Environmental Protection Commission (1972).

Table 2-25. Surface values of chlorophyll a (mg/m^3), 1952-1966, and primary production (g/(m^2)(d)) of carbon, 1962-1966, for areas of Tampa Bay, Florida[a] (Sheet 1 of 3)

Area	1952-53		1958		1962		1963		1964		1965		1966	
	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.
Area I--Old Tampa Bay:														
January	2.0						3.3	0.32			1.6	0.44	8.1	0.22
February							1.7	0.11					3.5	0.14
March							6.8	0.72	4.0	0.34	2.4	0.29	3.6	0.16
April	3.1						9.4	0.61	6.3	1.34	7.1	0.81	5.0	0.24
May	3.1						3.9	0.54	3.7	0.61	2.1	0.35	9.8	0.37
June							10.4	1.26	1.8	0.29			5.0	0.28
July							20.0	0.90	5.3	0.48			5.1	0.22
August							8.9	0.96	3.9	0.32	26.6	1.26	7.7	0.43
September	9.9				10.9		15.2	0.56	2.6	0.32	9.1	0.52	5.0	0.28
October					15.2	0.97	5.9	0.51			8.9	0.41	6.5	0.46
November					5.0	0.39			5.1	0.45	11.8	0.56	3.1	0.17
December					6.4	0.41			12.6	1.13	8.1	0.30	5.2	0.25
Yearly mean	4.5				9.4	0.59	8.6	0.65	5.0	0.59	8.6	0.55	5.6	0.27
Area II--Hillsborough Bay:														
January	4.6						25.9	1.79			5.5			
February							9.3	0.71				0.77		
March							25.7	0.57	8.3	0.51	7.1			
April	4.6						4.7	0.23	27.5	1.41	3.6	0.79		
May	7.9						16.1	1.26	0.8	0.33	6.0	0.43		
June							4.9	0.25	1.6	0.13		0.99		
July							27.1	1.66	13.7	2.08				
August							35.4	1.49	26.5	1.43				
September	13.3				18.8		29.0	0.79	16.2	0.70				
October					10.2	0.19	11.3	0.77						
November					14.7	0.95			4.9	0.23				
December					16.0	0.61			8.2	0.62				
Yearly mean	7.6				14.9	0.58	18.9	0.95	12.0	0.83	5.6	0.75		

Note: See footnote at end of table.

Table 2-25. Surface values of chlorophyll a (mg/m^3), 1952-1966, and primary production (g/(m^2)(d)) of carbon, 1962-1966, for areas of Tampa Bay, Florida[a] (Sheet 2 of 3)

Area	1952-53		1958		1962		1963		1964		1965		1966	
	Chlor. a	Pri-mary prod.	Chlor. a	Pri-mary prod.	Chlor. a	Pri-mary prod.	Chlor. a	Pri-mary prod.	Chlor. a	Pri-mary prod.	Chlor. a	Pri-mary prod.	Chlor. a	Pri-mary prod.
Area III—Tampa Bay:														
January							2.2	0.53			1.0	0.14	7.6	0.26
February							10.4	0.82					6.4	0.26
March							5.7	0.64	4.7	0.54	5.5	0.65	5.6	0.26
April	6.9						11.5	0.64	13.4	0.62	5.4	0.37	6.3	0.31
May							4.4	0.42	4.1	0.43	3.1		4.1	0.16
June							3.6	0.21	0.6	0.30			5.3	0.30
July							3.0	0.19	10.6	0.77			8.4	0.36
August							3.9	0.43	4.3	0.37	10.8	0.52	12.7	0.65
September	9.3				7.5		9.2	0.56	8.7	0.50	22.4	0.74		
October					5.0	0.57	5.1	0.22			4.8	0.22		
November					11.0	0.73			3.7	0.21	10.5	0.52		
December					3.0	0.31	7.6	0.59	2.6	0.16	10.7	0.44		
Yearly mean	8.1				6.6	0.53	6.1	0.48	5.9	0.43	8.3	0.45	7.1	0.32
Area IV—Tampa Bay Entrance:														
January	1.7										2.2	0.30	1.2	0.04
February							2.8	0.32					3.3	0.14
March							1.6	0.21	1.7	0.38	3.9	0.66	2.3	0.10
April							1.9	0.27	3.0	0.54	2.4	0.36	1.4	0.07
May	3.1						6.1	0.69	0.7	0.23	1.2	0.10	2.5	0.11
June							9.3	0.54	0.4	0.07			2.6	0.10
July							3.3	0.47	2.9	0.14			8.4	0.40
August							2.8	0.28	3.1	0.31			6.9	0.35
September	10.0				1.6		6.0	0.75	5.3	0.79	9.9	0.52	8.2	0.46
October					8.2	0.57	1.9	0.25			8.9	0.37	21.1	0.95
November					5.0	0.49			11.4	0.57	3.2	0.15	5.9	0.22
December					5.7	0.41	3.8	0.16	0.7	0.12	6.4	0.26		
Yearly mean	4.9				5.1	0.49	4.0	0.39	3.2	0.35	4.8	0.34	5.8	0.27

Note: See footnote at end of table.

Table 2-25. Surface values of chlorophyll a (mg/m^3), 1952-1966, and primary production (g/(m^2)(d)) of carbon, 1962-1966, for areas of Tampa Bay, Florida[a] (Sheet 3 of 3)

Area	1952-53		1958		1962		1963		1964		1965		1966	
	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.	Chlor. a	Primary prod.
Area V--Boca Ciega Bay:														
January							7.5	0.30	11.1	0.47			9.1	0.30
February							7.9	0.27	7.4	0.32			1.8	0.07
March							6.2	0.30	7.9	0.41			19.3	0.89
April	5.1						3.8	0.28	4.5	0.30			13.8	0.67
May	3.4						5.0	0.34	3.4	0.22			4.7	0.18
June					9.0	0.71	6.5	0.37	3.9	0.25			15.8	0.89
July			3.5		8.3	0.51	7.6	0.43					10.6	0.45
August					8.7	0.44	6.2	0.36					9.2	0.53
September					9.0	0.44	10.0	0.46			5.1	0.26	8.1	0.47
October					8.8	0.47	5.0	0.27			10.1	0.41	11.6	0.61
November	3.1				9.2	0.40	6.7	0.31			9.0	0.41	5.5	0.31
December					7.4	0.32	9.5	0.40			15.0	0.59	7.1	0.41
Yearly mean	3.9		3.5		8.6	0.47	6.8	0.34	6.4	0.33	9.8	0.42	9.7	0.48

[a] From Taylor and Saloman (1968b).

Table 2-26. Ranges of abundance of phytoplankton cells recorded from aliquots for the Tampa Bay system, fall 1969 to spring-summer 1971[a] (Values expressed as 10^6 cells per liter) (Sheet 1 of 3)

Species	Fall 1969	Winter 1970	Spring 1970	Summer 1970	Fall 1970	Winter 1971	Spring-summer 1971
Diatoms							
Actinoptychus undulatus	0.1						
Amphora marina		0.1	0.1				
Asterionella japonica	0.8-1.2	0.2-0.9			0.6		
Bacillaria paradoxa				0.4			0.4
Bacteriastrum comosum			0.5				1.3
Bellerochea malleus	0.1-0.5	0.1-0.4	0.1-0.6	0.1-0.4	0.4	0.2	0.2
Biddulphia mobilensis	0.1						
Biddulphia regia	0.1		0.1-0.5	0.1			
Ceratsulina pelagica	0.2	0.2-3.3	0.1-0.3	0.2		0.8	
Chaetoceros decipiens	0.6					0.4	
Chaetoceros sp. "A"			0.5-1.1				
Coscinodiscus centralis		0.1					
Coscinodiscus radiatis	0.1						0.1
Cyclotella sp.				0.3			
Ditylum brightwelli			0.1				
Gyrosigma balticum	0.1			0.1	0.1		
Lauderia borealis	0.1-0.2	0.7					0.4
Navicula clavata	0.1			0.1			
Navicula wawrikae	0.1		0.1				
Nitzschia closterium	0.1						
Nitzschia pungens var. *atlantica*	0.1-0.5			0.1-0.2	0.4	0.3	
Nitzschia sp.				0.1			
Paralia sulcata	0.1-0.2		0.4	0.3			
Pleurosigma angulatum	0.1						
Pleurosigma formosum				0.1			

Note: See footnotes at end of table.

Table 2-26. Ranges of abundance of phytoplankton cells recorded from aliquots for the Tampa Bay system, fall 1969 to spring-summer 1971[a] (Values expressed as 10^6 cells per liter) (Sheet 2 of 3)

Species	Fall 1969	Winter 1970	Spring 1970	Summer 1970	Fall 1970	Winter 1971	Spring-summer 1971
Diatoms (continued)							
Pleurosigma stringosum	0.1	0.1		0.1			
Rhizosolenia alata	0.1-0.5	0.1	0.1	0.1			
Rhizosolenia alata f. gracillima	0.1				0.1	0.2	
Rhizosolenia calcar avis		0.1	0.1				
Rhizosolenia hebetata f. semispina		0.1-0.4					
Rhizosolenia fragilissima			0.4				
Rhizosolenia robusta			0.1				
Rhizosolenia setigera	0.1		0.2		0.1	0.1	0.1
Rhizosolenia stolterfothii	0.1-0.6	0.2	0.1-0.8	0.3		0.1	0.1
Skeletonema costatum	0.1-19.4	0.3-3.4	0.4-2.3	0.3-1.4	0.3-1.7	0.4-0.7	0.4-1.5
Thalassionema nitzschioides	0.3-0.6	0.2-0.4	0.2-1.0	0.2			
Thalassiosira aestivalis	0.8-2.2		0.4				
Thalassiothrix mediterranea var. pacifica	0.1						
Tropidoneis lepidoptera	0.1-0.4		0.9-1.7	0.1			0.7
Dinoflagellates							
Ceratium furca	0.1	0.2	0.1	0.1			
Ceratium fusus	0.1	0.1		0.1			
Ceratium hircus	0.1-0.3	0.1-0.4	0.1	0.1-0.5			
Ceratium trichoceros				0.1			

Note: See footnotes at end of table.

Table 2-26. Ranges of abundance of phytoplankton cells recorded from aliquots for the Tampa Bay system, fall 1969 to spring-summer 1971[a] (Values expressed as 10^6 cells per liter) (Sheet 3 of 3)

Species	Fall 1969	Winter 1970	Spring 1970	Summer 1970	Fall 1970	Winter 1971	Spring-summer 1971
Dinoflagellates (continued)							
Ceratium tripos var. *atlanticum*			0.1				0.1
Dinophysis caudata f. *acutiformis*	0.1						
Gonyaulax balechii	0.1-1.0	0.1-0.3	0.1-2.6	0.1-0.3		0.1	
Gonyaulax diacantha		0.1	0.1	0.1			
Gonyaulax diegensis		0.1			0.1		
Gonyaulax digitalis		0.1-0.2		0.1			
Gonyaulax monilata				0.2			
Gonyaulax polygramma	0.2		0.1-0.2				
Gymnodinium splendens				0.1		0.2-0.3	
Ornithocercus steinii				0.1			
Ornithocercus thumii[b]		0.1	0.2				
Peridinium abei[b]	0.1						
Peridinium claudicans[b]	0.1						
Peridinium conicum[b]			0.1	0.1			
Peridinium oblongum[b]	0.1	0.1	0.1	0.1			
Peridinium pellucidum[b]	0.1	0.1-0.2	0.1				
Peridinium spiniferum[b]				0.1			
Peridinium tuba[b]			0.1				
Prorocentrum micans	0.1	0.1					
Other							
Chlorella-like-S-14	0.1-0.2	0.1	0.2-0.3	0.1			

[a] Adapted from Turner and Hopkins (1974).

[b] Nonchloroplast-bearing cells.

Table 2-27. Algae reported from the Tampa Bay area[a]
(Sheet 1 of 4)

Cyanophyta

Agmenellum quadruplicatum
Agmenellum thermale
Anacystis aeruginosa
Anacystis dimidiata
Anacystis montana
Coccochloris elabens
Gomphosphaeria aponina
Johannesbaptistia pellucida
Entophysalis conferta
Entophysalis deusta
Arthrospira brevis
Microcoleus lyngbyaceus
Microcoleus vaginatus
Oscillatoria erythraea
Oscillatoria lutea
Oscillatoria princeps
Porphyrosiphon notarisii
Schizothrix arenaria
Schizothrix calcicola
Schizothrix mexicana
Spirulina subsalsa
Anabaena fertilissima
Hormothamnion enteromorphoides
Nodularia spumigena
Calothrix confervicola
Calothrix crustacea
Calothrix parietina
Calothrix pilosa
Dichothrix fucicola
Rivularia atra
Rivularia nitida
Rivularia polyotis
Mastigocoleus testarum
Stigonema aerugineum

Chlorophyta

Pseudotetraspora antillarum
Gomontia polyrhiza
Diplochaete solitaria
Entocladia flustrae
Entocladia viridis
Phaeophila dendroides
Pringsheimiella scutata
Protoderma marinum
Ulvella lens
Stichococcus marinus
Enteromorpha chaetomorphoides
Enteromorpha clathrata
Enteromorpha compressa
Enteromorpha flexuosa
Enteromorpha intestinalis
Enteromorpha lingulata
Enteromorpha linza
Enteromorpha prolifera
Enteromorpha ramulosa
Enteromorpha salina
Monostroma oxyspermum
Ulva fasciata
Ulva lactuca
Derbesia vaucheriaeformis
Bryopsis hypnoides
Bryopsis pennata
Bryopsis plumosa
Caulerpa ashmeadii
Caulerpa fastigiata
Caulerpa lanuginosa
Caulerpa mexicana
Caulerpa paspaloides
Caulerpa peltata
Caulerpa prolifera
Caulerpa racemosa
Caulerpa sertularioides
Avrainvillea asarifolia
Avrainvillea levis
Avrainvillea elliottii
Avrainvillea nigricans
Boodleopsis pusilla
Codium decorticatum
Codium isthmocladum
Codium taylori
Halimeda discoidea
Halimeda incrassata
Halimeda monile
Halimeda opuntia
Penicillus capitatus
Penicillus dumetosus
Penicillus lamourouxii
Pseudocodium floridanum

Note: See footnote at end of table.

Table 2-27. Algae reported from the Tampa Bay area[a]
(Sheet 2 of 4)

Chlorophyta (continued)

Rhipoccphalus phoenix
Udotea conglutinata
Udotea cyathiformis
Udotea flabellum
Ostreobium quecketii
Chaetomorpha aerea
Chaetomorpha brachygona
Chaetomorpha linum
Chaetomorpha minima
Cladophora catenata
Cladophora delicatula
Cladophora fascicularis
Cladophora frascatii
Cladophora glaucescens
Cladophora gracilis
Cladophora longicellulata
Cladophora repens
Cladophora scitula
Rhizoclonium hookeri
Rhizoclonium kochianum
Rhizoclonium riparium
Anadyomene menziesii
Anadyomene stellata
Cladophoropsis membrenacea
Cystodictyon pavonium
Struvea pulcherrima
Valonia ventricosa
Acetabularia crenulata
Acetabularia farlowii
Acicularia schenckii
Batophora oerstedi

Chrysophyta

Vaucheria thuretii

Phaeophyta

Acinetospora crinita
Bachelotia antillarum
Ectocarpus dasycarpus
Ectocarpus elachistaeformis
Ectocarpus intermedius
Ectocarpus siliculosus
Giffordia conifera
Giffordia indica
Giffordia mitchelliae
Giffordia rallsiae
Sphacelaria furcigera
Sphacelaria tribuloides
Dictyopteris delicatula
Dictyota cervicornis
Dictyota ciliolata
Dictyota dentata
Dictyota dichotoma
Dictyota divaricata
Dictyota linearis
Dilophus alternans
Lobophora variegata
Padina vickersiae
Spatoglossum schroederi
Cladosiphon occidentalis
Cladosiphon zosterae
Ascocyclus orbicularis
Myrionema strangulans
Nemacystus howei
Stilophora rhizodes
Sporochnus bolleanus
Sporochnus pedunculatus
Stictyosiphon subsimplex
Colpomenia sinuosa
Myriotrichia occidentalis
Myriotrichia subcorymbosa
Rosenvingea intricata
Sargassum filipendula
Sargassum fluitans
Sargassum hystrix
Sargassum natans
Sargassum polyceratium
Sargassum pteropleuron

Note: See footnote at end of table.

Table 2-27. Algae reported from the Tampa Bay area[a]
(Sheet 3 of 4)

Rhodophyta

Asterocystis ramosa
Erythrocladia subintegra
Erythrotrichia carnea
Goniotrichum alsidii
Acrochaetium avrainvilleae
Acrochaetium sargassi
Acrochaetium seriatum
Acrochaetium thuretii
Kylinia crassipes
Galaxaura obtusata
Scinaia complanata
Gelidiella acerosa
Gelidium crinale
Gelidium pusillum
Pterocladia americana
Wurdemannia miniata
Hildenbrandia prototypus
Peyssonnelia rubra
Amphiroa fragilissima
Amphiroa rigida
Corallina cubensis
Fosliella atlantica
Fosliella farinosa
Fosliella lejolisii
Goniolithon decutescens
Jania adhaerens
Jania capillacea
Jania pumila
Lithothamnium occidentale
Lithothamnium syntrophicum
Grateloupia filicina
Halymenia agardhii
Halymenia floresia
Halymenia gelinaria
Halymenia pseudofloresia
Kallymenia limminghii
Kallymenia perforata
Gracilaria armata
Gracilaria blodgettii
Gracilaria cervicornis
Gracilaria compressa
Gracilaria cylindrica
Gracilaria damaecornis
Gracilaria debilis
Gracilaria foliifera
Gracilaria mammillaris
Gracilaria verrucosa
Gracilariopsis sjoestedtii
Catenella repens
Agardhiella ramosissima
Agardhiella tenera
Eucheuma acanthocladum
Eucheuma isiforme
Eucheuma nudum
Meristotheca floridana
Hypnea cervicornis
Hypnea cornuta
Hypnea musciformis
Hypnea spinella
Champia parvula
Lomentaria baileyana
Lomentaria rawitscheri
Botryocladia occidentalis
Chrysymenia enteromorpha
Fauchea hassleri
Fauchea peltata
Callithamnion byssoides
Callithamnion cordatum
Callithamnion roseum
Centroceras clavulatum
Ceramium byssoideum
Ceramium codii
Ceramium corniculatum
Ceramium fastigiatum
Ceramium floridanum
Ceramium strictum
Ceramium subtile
Crouania attenuata
Griffithsia globulifera
Griffithsia tenuis
Seirospora occidentalis
Spermothamnion turneri
Spyridia filamentosa
Caloglossa leprieurii
Cryptopleura fimbriata
Grinnellia americana
Hypoglossum tenuifolium
Taenioma nanum
Acanthophora muscoides
Acanthophora spicifera
Bostrychia binderi
Bostrychia calliptera

Note: See footnote at end of table.

Table 2-27. Algae reported from the Tampa Bay area[a]
(Sheet 4 of 4)

Rhodophyta (continued)

Bostrychia moritziana
Bostrychia radicans
Bostrychia scorpioides
Bostrychia tenella
Brongniartella mucronata
Bryocladia cuspidata
Chondria cnicophylla
Chondria collinsiana
Chondria dasyphylla
Chondria floridana
Chondria leptacremon
Chondria littoralis
Chondria sedifolia
Chondria tenuissima
Digenia simplex
Falkenbergia hillebrandii
Herposiphonia secunda
Herposiphonia tenella
Laurencia gemmifera
Laurencia intricata
Laurencia microcladia
Laurencia obtusa
Laurencia papillosa
Laurencia poitei
Lophosiphonia cristata
Lophosiphonia saccorhiza
Murrayella periclados
Polysiphonia denudata
Polysiphonia echinata
Polysiphonia ferulacea
Polysiphonia gorgoniae
Polysiphonia hapalacantha
Polysiphonia havanensis
Polysiphonia howei
Polysiphonia macrocarpa
Polysiphonia opaca
Polysiphonia ramentacea
Polysiphonia subtilissima
Polysiphonia tepida
Wrightiella tumanowiczi
Dasya corymbifera
Dasya pedicellata
Dasyopsis antillarum

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[a] Adapted from Dawes (1974).

Table 2-28. Seasonal abundance of zooplankton in the Tampa Bay complex[a]

	Fall Oct.-Nov. 1969	Winter Jan.-Feb. 1970	Spring May 1970	Summer Aug. 1970
Temperature (^oC)	24.0	16.3	27.0	29.6
Zooplankton (mg dry wt/m^3)	31.7	3.7	41.5	54.1
Zooplankton (number per cubic meter)	93,100[b]	12,700	106,500	108,600
Meroplankton	7,800	3,300	25,200	17,200
Copepods, post-naupliar	23,200	2,800	38,200	49,700
Copepod nauplii	35,600	5,000	33,500	19,500
Oithona colcarva	12,100	1,000	24,000	24,300
Acartia tonsa	3,800	800	4,200	5,600
Paracalanus crassirostris	4,400	300	1,700	9,600
Oikopleura dioica	2,800	20	5,000	6,300
Oithona simplex	640	0	0	370
Oithona nana	180	1	830	660
Euterpina acutifrons	140	5	220	50
Pseudodiaptomus coronatus	510	0	240	530
Labidocera aestiva	140	0	240	150
Evadne tergestina	140	0	1,300	0
Pelecypod larvae	4,200	1,200	15,500	5,300
Gastropod larvae	360	40	2,000	3,300
Polychaete larvae	1,000	370	670	3,800
Cirriped larvae	1,500	990	4,600	1,600
Decapod larvae	30	0	190	90
Echinoderm larvae	60	0	220	1,000
Bryozoan larvae	340	160	110	880

[a] From Hopkins (1977).

[b] Averages based on weighted means for each section of the bay.

Table 2-29. Biomass contribution of various components of the zooplankton in the Tampa Bay system, 1969-1970[a]

Plankton category	(mg dry weight/m^3)	Percentage
Acartia tonsa	11.87	30.01
Oithona colcarva	7.92	20.02
Paracalanus crassirostris	2.20	5.56
Oikopleura dioica	1.85	4.68
Evadne tergestina	0.91	2.30
Pseudodiaptomus coronatus	0.33	0.83
Labidocera aestiva	0.29	0.73
Oithona nana	0.26	0.66
Euterpina acutifrons	0.16	0.40
Oithona simplex	0.14	0.35
Other copepods (post-naupliar)	1.11	2.81
Copepod nauplii	2.36	5.97
Meroplankton	3.05	7.71
Other zooplankton	7.11	17.97
Total zooplankton	39.56	100.00

[a] From Hopkins (1977).

Table 2-30. Plankton abundance, chlorophyll, and salinity values for various regions of the Tampa Bay system, 1969-1970[a]

Parameter	Hillsborough Bay	Old Tampa Bay	Manatee River	Upper Tampa Bay	Mid Tampa Bay	Lower Tampa Bay	Boca Ciega Bay
Salinity (parts per thousand)	19.5 (16.9-20.6)[b]	21.0 (19.0-25.7)	22.2 (19.0-25.7)	23.3 (22.1-24.0)	28.0 (24.0-28.9)	30.0 (29.3-32.3)	31.4 (30.4-31.6)
Chlorophyll a + phaeopigments (mg/m^3)	53.6 (25.7-68.1)	11.3 (9.9-21.1)	12.8 (11.3-15.9)	15.1 (13.1-20.7)	13.1 (5.3-17.5)	3.5 (2.7-9.6)	11.9 (7.1-16.8)
Zooplankton biomass (mg dry wt/m^3)	43.4 (0.7-79.8)	70.2 (26.1-71.9)	128.2 (92.4-171.2)	33.9 (17.6-48.0)	24.5 (8.9-35.4)	22.9 (16.6-45.1)	33.8 (13.9-55.9)
Zooplankton numbers ($No./m^3$)	103,000 (4,836-280,839)	110,000 (95,967-185,794)	145,000 (130,015-311,909)	76,000 (37,098-149,676)	73,000 (22,038-79,047)	48,000 (32,145-70,287)	82,000 (56,186-141,505)

[a] Adapted from Hopkins (1977).

[b] Ranges in parentheses.

Table 2-31. Abundance (median number per cubic meter) of the most numerous types of holoplankton in various regions of the Tampa Bay system, 1969-1970[a]

Species	Hillsborough Bay	Old Tampa Bay	Manatee River	Upper Tampa Bay	Mid Tampa Bay	Lower Tampa Bay	Boca Ciega Bay	Tampa Bay average[b]
Oithona colcarva	16,558 (370-67,851)[c]	27,394 (7,192-36,991)	41,003 (29,544-131,657)	18,597 (6,734-28,192)	11,496 (4,657-33,346)	9,865 (867-16,529)	29,897 (5,904-29,937)	17,942
Acartia tonsa	4,768 (434-27,767)	12,326 (3,599-26,247)	26,672 (18,024-130,951)	2,216 (1,052-9,985)	2,278 (1,566-14,615)	3,570 (1,344-6,261)	3,049 (1,730-11,265)	5,289
Paracalanus crassirostris	228 (22-8,839)	6,715 (2,837-12,804)	1,594 (100-7,673)	3,309 (598-14,623)	4,143 (1,166-15,492)	4,110 (2,432-11,212)	6,188 (1,961-11,882)	4,153
Oikopleura dioica	3,089 (57-9,507)	7,364 (1,195-11,343)	4,907 (1,503-7,327)	4,074 (2,342-7,136)	2,409 (1,788-5,227)	1,796 (109-2,118)	4,034 (1,988-9,569)	3,792
Evadne tergestina	173 (0-12,687)	1,550 (87-3,567)	20 (11-118)	2,195 (59-12,663)	42 (0-498)	66 (0-211)	37 (9-306)	759
Oithona nana	1 (0-38)	1 (0-9)	1 (0-455)	8 (0-153)	601 (12-2,080)	1,617 (834-2,395)	607 (85-972)	499
Pseudodiaptomus coronatus	19 (0-783)	944 (703-2,695)	985 (654-2,210)	328 (14-555)	167 (50-928)	101 (0-353)	126 (79-276)	334
Oithona simplex	1 (0-47)	0 (0)	1 (0-23)	31 (0-276)	154 (0-273)	976 (114-2,491)	378 (106-924)	259
Euterpina acutifrons	3 (0-28)	8 (0-163)	519 (22-653)	41 (0-257)	250 (43-484)	344 (84-368)	384 (224-464)	171
Labidocera aestiva	25 (0-156)	132 (0-594)	20 (6-67)	162 (17-689)	169 (120-386)	246 (14-594)	120 (53-126)	155
Total copepods (post naupliar)	21,677 (858-97,450)	51,382 (14,286-67,928)	78,060 (52,837-263,978)	28,275 (11,921-42,101)	21,605 (8,628-64,736)	19,442 (12,087-28,108)	49,282 (10,350-50,772)	31,210
Copepod nauplii	29,787 (2,088-44,189)	49,080 (22,407-79,598)	38,736 (25,528-69,548)	24,888 (8,143-50,171)	26,644 (5,794-34,848)	12,169 (7,617-18,137)	31,933 (13,706-37,400)	28,716

[a] Adapted from Hopkins (1977).
[b] Tampa Bay averages weighted as in Table 2-28.
[c] Ranges in parentheses.

Table 2-32. Abundance (median number per cubic meter) of major larval plankton groups in various regions of the Tampa Bay system, 1969-1970[a]

Group	Hillsborough Bay	Old Tampa Bay	Manatee River	Upper Tampa Bay	Mid Tampa Bay	Lower Tampa Bay	Boca Ciega Bay	Tampa Bay average[b]
Pelecypod	9,986 (587-15,784)[c]	4,673 (1,239-31,358)	6,197 (625-7,395)	13,892 (1,011-31,925)	7,157 (797-25,667)	5,956 (2,479-17,587)	6,955 (4,824-9,467)	7,973
Cirriped	2,125 (430-25,839)	5,057 (3.85-22,812)	5,690 (1,491-5,956)	1,161 (189-8,611)	1,081 (610-7,601)	1,109 (357-2,576)	2,593 (269-3,823)	2,175
Polychaete	915 (176-12,306)	2,611 (892-5,921)	984 (940-1,445)	1,558 (325-6,118)	1,342 (460-2,347)	798 (603-3,408)	3,591 (1,007-5,354)	1,616
Gastropod	425 (135-744)	427 (188-1,156)	3,231 (869-4,438)	709 (174-2,310)	1,962 (274-8,259)	3,525 (1,691-13,093)	1,656 (490-4,139)	1,585
Echinoderm	11 (0-279)	86 (0-320)	0 (1)	494 (0-3,774)	738 (66-1,708)	451 (0-493)	1,203 (60-2,183)	448
Bryozoan	249 (99-1,250)	357 (98-1,348)	374 (283-395)	399 (41-1,835)	304 (141-555)	190 (82-614)	791 (164-929)	337
Decapod	124 (0-224)	28 (0-80)	28 (11-132)	210 (49-644)	66 (46-158)	139 (62-380)	75 (36-100)	106
Total mero-plankton	17,109 (1,727-5,2073)	17,017 (6,562-39,475)	15,228 (6,900-19,660)	18,756 (6,576-46,287)	13,826 (5,197-44,321)	11,133 (9,986-34,117)	16,045 (12,341-19,608)	15,358

[a] Adapted from Hopkins (1977).

[b] Tampa Bay averages weighted as in Table 2-28.

[c] Ranges in parentheses.

Table 2-33. Total mean densities (number per 100 cubic meters) of ichthyoplankton and planktonic stages of commercially important invertebrates taken at the intake station located near the A. W. Higgins powerplant and bay stations (mean of four stations) in upper Old Tampa Bay from March through November 1978[a]
(Sheet 1 of 3)

Life stage and taxon	Intake	Bay
Fishes		
Total eggs	2599.97	13913.94
Total yolk larvae	23.47	9.96
Total larvae	1790.20	867.62
Total ichthyoplankton	4413.64	14791.52
Eggs		
Clupeidae	0.06	16.65
Brevoortia spp.	0.03	46.82
Anchoa hepsetus	0.12	--
Anchoa mitchilli	2324.40	9931.60
Anchoa spp.	92.10	1502.76
Atherinidae	1.32	0.01
Membras martinica	0.10	0.01
Menidia beryllina	0.06	--
Oligoplites saurus (?)	4.24	15.60
Sciaenidae (?)	149.31	2137.52
Soleidae	0.02	0.67
Achirus lineatus	20.92	116.51
Trinectes maculatus	1.84	31.48
Type D	1.15	--
Type F	0.03	16.85
Type H	--	1.75
Type J	0.14	50.30
Type K	0.15	0.70
Type O	--	0.01
Type P (adhesive)	0.01	--
Type Q (demersal)	--	0.01
Type R	0.16	--
Unidentifiable (damaged)	3.82	44.71
Yolk larvae		
Clupeidae	0.01	0.07
Anchoa spp.	19.57	9.57
Gobiesox strumosus	0.01	0.05
Atherinidae	0.02	--
Membras martinica	0.13	0.06
Menidia beryllina	0.06	--
Gerreidae (?)	0.07	--
Sciaenidae	0.16	0.02
Hypsoblennius spp.	0.08	0.01

Note: See footnote at end of table.

Table 2-33. Total mean densities (number per 100 cubic meters) of ichthyoplankton and planktonic stages of commercially important invertebrates taken at the intake station located near the A. W. Higgins powerplant and bay stations (mean of four stations) in upper Old Tampa Bay from March through November 1978[a]
(Sheet 2 of 3)

Life stage and taxon	Intake	Bay
Fishes (continued)		
Yolk larvae (continued)		
Gobiidae	2.47	0.06
Gobiosoma oceanops (?)	0.02	--
Microgobius gulosus	0.77	--
Soleidae	0.01	0.01
Achirus lineatus	0.07	0.07
Trinectes maculatus	0.01	0.01
Unidentified	0.07	0.01
Unidentifiable (damaged)	0.03	0.04
Larvae		
Elops saurus	0.01	--
Clupeidae	0.01	0.01
Brevoortia patronus	0.47	0.09
Brevoortia smithi	0.20	0.01
Brevoortia spp.	0.02	0.06
Sardinella anchovia	0.08	--
Anchoa hepsetus	0.21	0.01
Anchoa mitchilli	50.36	23.05
Anchoa spp.	1479.71	701.43
Gobiesox strumosus	0.83	0.27
Exoccetidae	0.01	0.01
Hyporhamphus unifasciatus	--	0.01
Belonidae	0.01	--
Strongylura notata	0.01	--
Cyprinodontidae	0.01	--
Atherinidae	0.14	0.31
Membras martinica	9.69	9.60
Menidia beryllina	1.26	0.10
Hippocampus zosterae	0.01	--
Syngnathidae	--	0.01
Syngnathus spp.	0.65	0.43
Carangidae	0.01	0.03
Caranx crysos	--	0.01
Chloroscombrus chrysurus	0.24	0.64
Oligoplites saurus	0.02	0.01
Gerreidae	0.07	0.03
Orthopristis chrysoptera	0.01	--

Note: See footnote at end of table.

Table 2-33. Total mean densities (number per 100 cubic meters) of ichthyoplankton and planktonic stages of commercially important invertebrates taken at the intake station located near the A. W. Higgins powerplant and bay stations (mean of four stations) in upper Old Tampa Bay from March through November 1978[a]
(Sheet 3 of 3)

Life stage and taxon	Intake	Bay
Fishes (continued)		
Larvae (continued)		
Sparidae	--	0.01
Sciaenidae	1.64	2.26
Bairdiella chrysoura	3.64	0.85
Cynoscion arenarius	5.45	3.75
Cynoscion nebulosus	0.96	0.26
Menticirrhus saxatilis	0.01	0.01
Menticirrhus spp.	1.83	2.54
Pogonias cromis	0.07	0.01
Sciaenops ocellata	--	0.01
Blennidae	0.01	0.02
Hypsoblennius spp.	5.21	2.93
Eleotridae	--	0.01
Gobiidae	59.53	55.76
Gobiosoma bosci	1.79	0.20
Gobiosoma robustum	5.77	0.10
Gobiosoma spp.	13.94	0.79
Microgobius gulosus	11.92	0.58
Microgobius thalassinus	131.31	59.32
Triglidae	--	0.01
Prionotus spp.	0.01	0.06
Soleidae	0.02	0.06
Achirus lineatus	0.92	0.91
Trinectes maculatus	0.01	--
Symphurus plagiusa	0.01	0.09
Sphoeroides spp.	--	0.01
Unidentified	0.18	0.01
Unidentifiable (damaged)	1.08	1.00
Invertebrates		
Total commercial invertebrates	98.57	59.52
Lolliguncula brevis (larvae)	0.10	0.60
Penaeus duorarum (postlarvae)	0.79	0.81
Trachypenaeus spp. (postlarvae)	--	0.03
Menippe mercenaria (zoeae)	97.55	57.91
Callinectes sapidus (megalops)	0.13	0.17

[a] From NUS Corporation (1979).

Table 2-34. Scientific and common names of fishes and invertebrates taken in Tampa Bay macrozooplankton collections[a]
(Sheet 1 of 4)

Scientific name	Common name
Fishes	
Elopidae	Tarpons
Elops saurus	Ladyfish
Ophichthidae	Snake eels
Myrophis punctatus (T)	Speckled worm eel
Clupeidae	Herrings, shads
Brevoortia patronus	Gulf menhaden
Brevoortia smithi	Yellowfin menhaden
Brevoortia spp.	Menhaden
Harengula jaguana[b]	Scaled sardine
Sardinella anchovia	Spanish sardine
Engraulidae	Anchovies
Anchoa hepsetus	Striped anchovy
Anchoa mitchilli	Bay anchovy
Anchoa spp.	Anchovies
Gobiescocidae	Clingfishes
Gobiesox strumosus	Skilletfish
Exocoetidae	Halfbeaks
Belonidae	Needlefishes
Strongylura notata	Redfin needlefish
Cyprinodontidae	Killifishes
Fundulus grandis	Killifish
Atherinidae	Silversides
Membras martinica	Rough silverside
Menidia beryllina	Tidewater silverside
Syngnathidae	Pipefishes, seahorses
Hippocampus erectus	Lined seahorse
Hippocampus zosterae	Dwarf seahorse
Syngnathus (floridae)	Dusky pipefish
Syngnathus louisianae	Chain pipefish
Syngnathus spp.	Pipefishes
Carangidae	Jacks, pompanos
Caranx crysos	Blue runner
Chloroscombrus chrysurus	Atlantic bumper
Oligoplites saurus	Leatherjacket
Gerreidae	Mojarras
Pomadasyidae	Grunts
Orthopristis chrysoptera	Pigfish
Sparidae	Porgies
Argosargus probatocephalus	Sheepshead
Lagodon rhomboides	Pinfish
Sciaenidae	Drums
Bairdiella chrysoura	Silver perch
Cynoscion arenarius	Sand trout

Note: See footnotes at end of table.

Table 2-34. Scientific and common names of fishes and invertebrates taken in Tampa Bay macrozooplankton collections[a] (Sheet 2 of 4)

Scientific name	Common name
Fishes (continued)	
Sciaenidae (continued)	
Cynoscion nebulosus	Spotted seatrout
Leiostomus xanthurus	Spot
Menticirrhus americanus	Southern kingfish
Menticirrhus saxatilis	Northern kingfish
Menticirrhus spp.	Kingfishes
Pogonias cromis	Black drum
Sciaenops ocellata	Red drum
Ephippidae	Spadefishes
Chaetodipterus faber	Atlantic spadefish
Blenniidae	Combtooth blennies
Chasmodes sp.	Blenny
Hypsoblennius hentzi	Feather blenny
Hypsoblennius spp.	Blennies
Gobiidae	Gobies
Gobiosoma bosci	Naked goby
Gobiosoma oceanops	Neon goby
Gobiosoma robustum	Cobe goby
Gobiosoma spp.	Gobies
Microgobius gulosus	Clown goby
Microgobius thalassinus	Green goby
Triglidae	Searobins
Prionotus spp.	Searobins
Soleidae	Soles
Achirus lineatus	Lined sole
Trinectes maculatus	Hogchoker
Cynoglossidae	Tonguefishes
Symphurus plagiusa	Blackcheek tonguefish
Tetraodontidae	Puffers
Sphoeroides spp.	Puffers
Invertebrates	
Mollusca	
Cephalopoda	
Lolliguncula brevis	Brief squid
Arthropoda	
Stomatopoda	
Squilla spp.	Mantis shrimp
Decapoda	

Note: See footnotes at end of table.

Table 2-34. Scientific and common names of fishes and invertebrates taken in Tampa Bay macrozooplankton collections[a]
(Sheet 3 of 4)

Scientific name	Common name
Invertebrates (continued)	
Arthropoda (continued)	
Decapoda	
Penaeidae	
Penaeus duorarum	Pink shrimp
Trachypenaeus spp.	
Sicyonia spp.	
Sergestidae	
Lucifer faxoni	
Pasiphaeidae	
Leptochela spp.	
Palaemonidae	
Periclimenes americanus	
Periclimenes longicaudatus	
Periclimenes spp.	
Alpheidae	
Alpheus spp.	
Synalpheus spp.	
Ogyrididae	
Ogyrides limicola	
Hippolytidae	
Latreutes parvulus	
Hippolyte spp.	
Hippolysmata spp.	
Processidae	
Ambidexter symmetricus (?)	
Processa spp.	
Callianassidae	
Callianassa spp.	
Upogebia affinis	
Laomediidae	
Naushonia spp. (?)	
Porcellanidae	
Petrolisthes spp.	
Polyonyx gibbesi	
Paguridae	
Pagurus longicarpus	
Pagurus spp.	
Leucosiidae	
Persephona aquilonaris (?)	
Portunidae	
Callinectes sapidus	Blue crab
Xanthidae	
Eurypanopeus depressus	

Note: See footnotes at end of table.

Table 2-34. Scientific and common names of fishes and invertebrates taken in Tampa Bay macrozooplankton collections[a] (Sheet 4 of 4)

Scientific name	Common name
Invertebrates (continued)	
Xanthidae (continued)	
Hexapanopeus angustifrons	
Menippe mercenaria	Stone crab
Neopanope texana	
Panopeus herbstii	
Rithropanopeus harrisii	
Pinnotheridae	
Pinnotheres maculatus	
Pinnotheres spp.	
Pinnixa chaetopterana	
Pinnixa sayana	
Pinnixa spp.	
Grapsidae	
Sesarma cinereum	
Sesarma reticulatum	
Sesarma spp.	
Ocypodidae	
Uca spp.	

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[a] From Finucane (1966b, 1967); Phillips et al. (1977); Blanchet, Avery, and Leverone (1977); and NUS Corporation (1979).

[b] *H. pensacolae* (Whitehead 1973).

Table 2-35. Macroinvertebrates reported from Tampa Bay[a]
(Sheet 1 of 3)

Scientific name	Common name
Porifera	
Dysidea fragilis	
Halichondria bowerbanki	
Cliona celata	
Annelida	
Nereis sp.	
Sipunculida	
Siphonosoma cumanense	
Arthropoda	
Squilla empusa	Mantis shrimp
Penaeus duorarum	Pink shrimp
Sicyonia typica	
Trachypenaeus constrictus	
Trachypenaeus similis	
Caridea (unid.)	
Upogebia affinis	
Petrolisthes galathinus	
Petrolisthes armatus	
Emerita talpoida	Sand flea
Pagurus pollicaris	
Pagurus longicarpus	
Petrochirus diogenes	
Hypoconcha arcuata	
Dromidia antillensis	
Calappa flammea	Box crab
Persephona punctata	Purse crab
Hepatus epheliticus	Calico crab
Portunidae (juveniles)	
Portunus gibbesii	
Portunus spinimanus	
Arenaeus cribrarius	Speckled sand crab
Callinectes sapidus	Blue crab
Neopanope texana	
Neopanope packardii	
Menippe mercenaria	Stone crab
Eurypanopeus depressus	
Eurypanopeus sp.	
Panopeus herbstii	
Pilumnus sayi	

Note: See footnote at end of table.

Table 2-35. Macroinvertebrates reported from Tampa Bay[a]
(Sheet 2 of 3)

Scientific name	Common name
Arthropoda (continued)	
Hexapanopeus angustifrons	
Uca rapax	
Heterocrypta granulata	Triangle crab
Libinia dubia	Spider crab
Metoporhaphis calcarata	
Pitho anisodon	
Podochela riisei	
Limulus polyphemus	Horseshoe crab
Mollusca	
Crassostrea virginica	Eastern oyster
Laevicardium mortoni	Morton's egg cockle
Aequipecten irradians	Atlantic bay scallop
Echinochama cornuta	Florida spiny jewel box
Chione intapurpurea	Lady-in-waiting venus
Chione cancellata	Cross-barred venus
Martesia striata	Striate martesia
Brachidontes exustus	Scorched mussel
Barbatia candida	White bearded ark
Anadara transversa	Transverse ark
Macoma tenta	Tenta macoma
Mulinia lateralis	
Bulla occidentalis	Common West Indian bubble
Anachis avara	Greedy dove-shell
Prunum apicinum	Atlantic marginella
Batillaria minima	
Nassarius vibex	Common eastern nassa
Murex pomum	Apple murex
Urosalpinx perrugata	Gulf oyster drill
Eupleura sulcidentata	Sharp-ribbed drill
Terebra dislocata	Common Atlantic auger
Oliva sayana	Lettered oliva
Polinices duplicatus	Shark eye
Melongena corona	Crown conch
Cerithium floridanum	Florida cerith
Vermicularia sp.	Worm-shell
Aplysia spp.	Sea-hare
Bursatella leachi	Ragged sea-hare
Lolliguncula brevis	Brief squid
Octopus sp.	

Note: See footnote at end of table.

Table 2-35. Macroinvertebrates reported from Tampa Bay[a] (Sheet 3 of 3)

Scientific name	Common name
Echinodermata	
Astropecten articulatus	
Luidia clathrata	
Echinaster spinulosus	
Ophiophragmus wurdemani	
Ophiothrix angulata	
Ophioderma brevispinum	
Ophiolepis elegans	
Lytechinus variegatus	
Mellita quinquiesperforata	
Encope michelini	
Pentacta pygmaea	
Chordata	
Amaroucium pellucidum	Pink sea pork
Styela plicata	
Molgula spp.	

[a] Adapted from Dragovich and Kelly (1964b).

Table 2-36. Annelids, mollusks, and echinoderms reported from Tampa Bay[a]

(Sheet 1 of 6)

Annelida

Aglaophamus verrilli
Ammotrypane aulogaster
Amphitrite sp.
Ancistrosyllis jonesi
Aonides mayaguezensis
Apoprionospio pygmaea
Arabella iricolor
Arabella sp.
Arenicola cristata
Aricidea fragilis
Aricidea furcatus
Aricidea taylori
Aricidea sp.
Armandia agilis
Armandia sp.
Asabellides oculata
Autolytus cornutus
Autolytus sp.
Boguea enigmatica
Branchioasychis americana
Branchiomma nigromaculata
Branchiosyllis oculata
Brania clavata
Brania sp.
Cabira incerta
Capitella capitata
Capitella sp.
Capitellides jonesi
Capitomastus aciculatus
Caulleriella sp.
Ceratonereis irritabilis
Ceratonereis sp.
Chaetopterus variopedatus
Chone duneri
Chone sp.
Cirriformia filigera
Cirriformia grandis
Clymenella mucosa
Cylmenella torquata calida
Clymenella zonalis
Dasybranchus lumbricoides
Dasybranchus lunulatus
Dasybranchus sp.
Diopatra cuprea
Diospio uncinata
Drilonereis longa
Drilonereis magna
Drilonereis sp.
Enoplobranchus sanguineus
Eteone heteropoda
Eteone sp.
Eumida sanguinea
Eunice rubra
Euphrosine triloba
Exogone dispar
Exogone sp.
Fabricia sabella
Glycera americana
Glycera dibranchiata
Glycinde pacifica
Glycinde solitaria
Glycinde sp.
Goniadella sp.
Gyptis vittata
Gyptis sp.
Haploscoloplos sp.
Harmothoe aculeata
Harmothoe lunulata
Harmothoe sp.
Hesione picta
Heteromastus filiformis
Hydroides dianthus
Hydroides norvegica
Isolda pulchella
Laeonereis culveri
Lepidametria commensalis
Lepidonotus sublevis
Lepidonotus variabilis
Lepidonotus sp.
Loimia medusa
Loimia viridis
Loimia sp.
Lumbrineris coccinea
Lumbrineris erecta
Lumbrineris impatiens
Lumbrineris latreilli
Lumbrineris tenuis
Lumbrineris sp.
Lysarete brasiliensis
Magelona pettiboneae

Note: See footnote at end of table.

Table 2-36. Annelids, mollusks, and echinoderms reported from Tampa Bay[a]

(Sheet 2 of 6)

Annelida (continued)

Magelona sp.
Maldane sarsi
Marphyssa sanguinea
Megalomma bioculatum
Megalomma lobiferum
Melinna maculata
Minuspio cirrifera
Minuspio cirrobranchiata
Minuspio longibranchiata
Myriochele sp.
Naineris setosa
Naineris sp.
Namalycastis abiuma
Nematonereis hebes
Nephtys bucera
Nephtys magellanica
Nephtys picta
Nephtys squamosa
Nephtys sp.
Nereiphylla fragilis
Nereis arenaceodonta
Nereis occidentalis
Nereis succinea
Nereis sp.
Notomastus hemipodus
Notomastus latericeus
Notomastus lobatus
Odontosyllis enopla
Onuphis eremita oculata
Onuphis magna
Onuphis nebulosa
Onuphis sp.
Ophryotrocha puerilis
Orbinia kupfferi
Orbinia ornata
Owenia fusiformis
Paleanotus heteroseta
Paleanotus sp.
Parahesione luteola
Paranaites speciosa
Paraonis fulgens
Paraonis sp.
Paraprionospio pinnata
Pectinaria gouldii
Perinereis floridana

Petaloproctus socialis
Pherusa arenosa
Pherusa sp.
Pholoe sp.
Phyllodoce arenae
Phyllodoce sp.
Phyllohartmania taylori
Pilargis pacifica
Pionosyllis sp.
Pisione remota
Pista cristata
Pista palmata
Platynereis dumerilii
Podarke obscura
Poecilochaetus johnsoni
Polycirrus eximius
Polydora ligni
Polydora quadrilobata
Polydora socialis
Polydora websteri
Polydora sp.
Polyodontes lupina
Polyodontes sp.
Prionospio heterobranchia
Pseudeurythoe paucibranchiata
Pseudeurythoe sp.
Pseudopolydora sp.
Rullierinereis mexicana
Sabella microthalma
Sabellaria floridensis
Sabellaria gracilis
Sabellaria sp.
Salmacina dysteri
Scolelepis squamata
Scolelepis texana
Scoloplos foliosus
Scoloplos fragilis
Scoloplos riseri
Scoloplos robustus
Scoloplos rubra
Scoloplos sp.
Scyphoproctus platyproctus
Sigalion arenicola
Sigambra bassi
Sigambra tentaculata

Note: See footnote at end of table.

Table 2-36. Annelids, mollusks, and echinoderms reported from Tampa Bay[a]
(Sheet 3 of 6)

Annelida (continued)

Sigambra sp.
Sphaerosyllis sp.
Spio pettiboneae
Spio setosa
Spiochaetopterus oculatus
Spiophanes bombyx
Spirorbis spirillum
Stauronereis rudolphi
Stauronereis sp.
Stenorinereis martini
Sthenelais boa
Streblospio benedicti
Syllis aciculata
Syllis annularis
Syllis cornuta
Syllis gracilis
Syllis hyalina
Syllis spongicola
Syllis variegata
Syllis vittata
Syllis sp.
Terebella rubra
Tharyx dorsobranchialis
Thelepus setosus
Travisia sp.
Trichobranchus glacialis
Trochochaeta sp.

Mollusca

Abra aequalis
Acteocina sp.
Acteon punctostriatus
Aequipecten irradians
Amygdalum papyria
Anachis avara
Anachis obesa
Anachis ostreicola
Anachis semiplicata
Anadara transversa
Anatina plicatella
Anodontia alba
Anodontia phipippiana
Anomalocardia cuneimeris
Anomia simplex
Aplysia wilcoxi
Arca zebra
Arene tricarinata
Asthenothaerus sp.
Atrina rigida
Bankia gouldii
Barbatia cancellaria
Barbatia candida
Barbatia sp.
Barnea truncata
Batillaria minima
Bittium varium
Branchiodontes exustus
Bulla occidentalis
Bulla striata
Bullata ovuliformis
Bursatella leachi plei
Busycon contrarium
Busycon spiratum
Caecum cooperi
Caecum pulchellum
Caecum sp.
Calliostoma jujubinum tampaense
Calyptraea centralis
Cantharus multangulus
Cantharus tinctus
Cardita floridana
Cerithidea costata
Cerithiopsis emersoni
Cerithiopsis greeni
Cerithium muscarum
Cerithium floridanum
Cerithium variabile
Chaetopleura apiculata
Chama congregata
Chama macerophylla
Chione cancellata
Chione grus
Chione intapurpurea

Note: See footnote at end of table.

Table 2-36. Annelids, mollusks, and echinoderms reported from Tampa Bay[a]
(Sheet 4 of 6)

Mollusca (continued)

Chiton tuberculatus
Codakia orbiculata
Columbella rusticoides
Conus floridanus
Conus jaspideus
Conus stearnsi
Corbula barrattiana
Corbula caribaea
Corbula contracta
Corbula sp.
Crassinella lunulata
Crassostrea virginica
Crenella divaricata
Crepidula aculeata
Crepidula fornicata
Crepidula maculosa
Crepidula plana
Crepidula sp.
Crytopleura costata
Cumingia tellinoides
Cyclinella tenuis
Cyclostremiscus beavi
Cyclostremiscus suppressus
Cylichna bidentata
Dentalium antillarum
Dentalium eboreum
Dentalium sp.
Dinocardium robustum vanhyningi
Diodora cayenensis
Diplodonta punctata
Donax variabilis
Doris sp.
Dosinia discus
Dosinia elegans
Ensis minor
Epitonium angulatum
Epitonium humphreysi
Epitonium rupicola
Erato mangeriae
Ervilia concentrica
Erycina floridana
Erycina sp.
Eupleura sulcidentata
Fasciolaria hunteria
Fasciolaria tulipa
Glycymeris pectinata
Glyphoturris rugirina
Gouldia cerina
Haminoea antillarum
Haminoea succinea
Hyalina avenacea
Hyalina velei
Illex illecebrosus
Ischnochiton papillosus
Laevicardium mortoni
Lioberus castaneus
Lithophaga bisulcata
Littorina angulifera
Littorina irrorata
Loligo peali
Lolliguncula brevis
Lucina floridana
Lucina multilineata
Lyonsia hyalina floridana
Macoma brevifrons
Macoma constricta
Macoma tenta
Macrocallista maculata
Macrocallista nimbosa
Mactra fragilis
Marginella aureccincta
Martesia cuneiformis
Martesia striata
Meioceras nitidum
Melampus coffeus
Melanella bilineata
Melanella intermedia
Melanella hemphilli
Melanella sp.
Melongena corona
Mercenaria campechiensis
Mitrella lunata
Modiolus americanus
Modiolus demissus
Modiolus demissus granosissimus
Modulus modulus
Monilispira leucocyma
Montacuta floridana

Note: See footnote at end of table.

Table 2-36. Annelids, mollusks, and echinoderms reported from Tampa Bay[a]

(Sheet 5 of 6)

Mollusca (continued)

Mulinia lateralis
Murex cellulosus
Murex dilectus
Murex florifer
Murex pomum
Muricopsis osterearum
Musculus lateralis
Mysella planulata
Mysella sp.
Nassarius vibex
Natica pusilla
Neritina reclivata
Noetia ponderosa
Nucula proxima
Nuculana acuta
Octopus vulgaris
Odostomia acutidens
Odostomia impressa
Odostomia producta
Odostomia seminuda
Odostomia sp.
Oliva sayana
Olivella floralia
Olivella mutica
Olivella perplexa
Ostrea equestris
Ostrea frons
Pandora bushiana
Pandora trilineata
Parastarte triquetra
Persicula lavelleana
Petricola pholadiformis
Phacoides nassula
Pitar fulminata
Pitar simpsoni
Pleuroploca gigantea
Plicatula gibbosa
Polinices duplicatus
Polymesoda caroliniana
Prunum apicinum
Psammotreta intastriata
Pseudocyrena floridana
Pyrgocythara hemphilli
Retusa conaliculata
Rissoina chesneli
Sayella hemphilli
Seila adamsi
Seila sp.
Semele bellastriata
Semele proficua
Semele purpurascens
Semele sp.
Sinum perspectivum
Solemya occidentalis
Solemya velum
Spisula raveneli
Spisula solidissima
Stellatoma stellata
Strombus alatus
Tagelus divisus
Tagelus plebius
Tectonatica pusilla
Teinostoma cryptospira
Tellidora cristata
Tellina aequistriata
Tellina alternata
Tellina lineata
Tellina mera
Tellina tampaensis
Tellina texana
Tellina versicolor
Terebra concava vinosa
Terebra dislocata
Terebra protexta
Teredo sp.
Thais haemastoma floridana
Trachycardium egmontianum
Trachycardium muricatum
Transennella conradina
Transennella stimpsoni
Triphora nigrocincta
Truncatella pulchella
Turbo castaneus
Turbonilla conradi
Turbonilla dalli
Urosalpinx perrugata
Venericardia perplana
Venericardia tridentata
Vermicularia fargoi

Note: See footnote at end of table.

Table 2-36. Annelids, mollusks, and echinoderms reported from Tampa Bay[a]
(Sheet 6 of 6)

Echinodermata

Amphiodia pulchella
Amphioplus abditus
Amphioplus thrombodes
Arbacia punctulata
Astropecten articulatus
Astropecten duplicatus
Encope emarginata
Encope michelini
Hemipholis elongata
Leptosynapta sp.
Luidia alternata
Luidia clathrata
Lytechinus variegatus
Mellita quinquiesperforata
Micropholis atra
Micropholis gracillima
Moira atropos
Ophiactis savigny
Ophioderma brevispinum
Ophiolepis elegans
Ophionereis reticulata
Ophiophragmus filograneus
Ophiophragmus septus
Ophiophragmus wurdemani
Ophiothrix angulata
Pentacta pygmaea
Pentamera sp.
Sclerodactyla briareus
Verrillaster spinulosus

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[a] Adapted from U.S. Army Corps of Engineers (1974b).

Table 2-37. Relation between mollusk diversity and abundance, sediment type, and hydrologic conditions in four areas of Tampa Bay[a]

Area	Sta-tions	Species collected alive	Total species collected	Total families collected	Live individuals per sample, average	Salinity, average (ppt)	Sand and shell, average (wt. %)	Silt and clay, average (wt. %)	Dissolved oxygen, range at bottom (ml/ℓ)
Boca Ciega Bay (undredged areas)	24	155	167	67	60.5	32.6	91	9	1.6-7.4
Boca Ciega Bay (dredged areas)	7	5	5	5	1.0	32.6	15	85	0.4-7.4
Upper Tampa Bay	60	96	146	57	52	26.6	81	19	0.7-6.4
Old Tampa Bay	98	97	120	52	16,000[b]	23.8	92	8	1.5-6.1
Hillsborough Bay[c]	45	35	64	40	45	23.4	78	22	0-6.0

[a] From Taylor (1970).

[b] High numbers due to occurrence of *Bittium varium* (snail) associated with seagrasses and algae.

[c] Most living mollusks collected in Hillsborough Bay were collected from stations located in the most southern section.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 1 of 11)

Scientific name	Common name[a]
Orectolobidae	Carpet sharks
Ginglymostoma cirratum	Nurse shark
Rhincodontidae	Whale sharks
Rhincodon typus	Whale shark
Odontaspididae	Sand tigers
Odontaspis taurus	Sand tiger
Lamnidae	Mackerel sharks
Carcharodon carcharias	White shark
Isurus oxyrinchus	Shortfin mako
Carcharhinidae	Requiem sharks
Carcharhinus acronotus	Blacknose shark
Carcharhinus leucas	Bull shark
Carcharhinus limbatus	Blacktip shark
Carcharhinus milberti	Sandbar shark
Carcharhinus obscurus	Dusky shark
Galeocerdo cuvieri	Tiger shark
Mustelus canis	Smooth dogfish
Mustelus norrisi	Florida smoothhound
Negaprion brevirostris	Lemon shark
Rhizoprionodon terraenovae	Atlantic sharpnose shark
Sphyrnidae	Hammerhead sharks
Sphyrna lewini	Scalloped hammerhead
Sphyrna mokarran	Great hammerhead
Sphyrna tiburo	Bonnethead
Pristidae	Sawfishes
Pristis pectinata	Smalltooth sawfish
Pristis perotteti	Largetooth sawfish
Rhinobatidae	Guitarfishes
Rhinobatos lentiginosus	Atlantic guitarfish
Torpedinidae	Electric rays
Narcine brasiliensis	Lesser electric ray
Rajidae	Skates
Raja eglanteria	Clearnose skate
Raja texana	Roundel skate
Dasyatidae	Stingrays
Dasyatis americana	Southern stingray
Dasyatis sabina	Atlantic stingray
Dasyatis sayi	Bluntnose stingray
Gymnura micrura	Smooth butterfly ray
Myliobatidae	Eagle rays
Aetobatus narinari	Spotted eagle ray
Rhinoptera bonasus	Cownose ray
Mobulidae	Mantas
Manta birostris	Atlantic manta
Acipenseridae	Sturgeons
Acipenser oxyrhynchus	Atlantic sturgeon

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 2 of 11)

Scientific name	Common name[a]
Lepisosteidae	Gars
Lepisosteus osseus	Longnose gar
Lepisosteus platyrhincus	Florida gar
Elopidae	Tarpons
Elops saurus	Ladyfish
Megalops atlantica	Tarpon
Albulidae	Bonefishes
Albula vulpes	Bonefish
Anguillidae	Freshwater eels
Anguilla rostrata	American eel
Muraenidae	Morays
Gymnothorax moringa	Spotted moray
Gymnothorax nigromarginatus	Blackedge moray
Congridae	Conger eels
Conger oceanicus	Conger eel
Ophichthidae	Snake eels
Ahlia egmontis	Key worm eel
Bascanichthys scuticaris	Whip eel
Bascanichthys teres	Sooty eel
Letharchus velifer	Sailfish eel
Myrophis punctatus	Speckled worm eel
Mystriophis intertinctus	Spotted spoon-nose eel
Mystriophis mordax	Snapper eel
Mystriophis punctifer	Stippled spoon-nose eel
Ophichthus gomesi	Shrimp eel
Ophichthus ocellatus	Palespotted eel
Clupeidae	Herrings
Brevoortia patronus	Gulf menhaden
Brevoortia smithi	Yellowfin menhaden
Dorosoma cepedianum	Gizzard shad
Dorosoma petenense	Threadfin shad
Etrumeus teres	Round herring
Harengula jaguana[b]	Scaled sardine
Opisthonema oglinum	Atlantic thread herring
Sardinella anchovia	Spanish sardine
Sardinella brasiliensis	Orangespot sardine
Engraulidae	Anchovies
Anchoa cubana	Cuban anchovy
Anchoa hepsetus	Striped anchovy
Anchoa mitchilli	Bay anchovy
Synodontidae	Lizardfishes
Saurida brasiliensis	Largescale lizardfish
Saurida normani	Shortjaw lizardfish
Synodus foetens	Inshore lizardfish
Synodus intermedius	Sand diver
Trachinocephalus myops	Snakefish

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 3 of 11)

Scientific name	Common name[a]
Cyprinidae	Minnows and carps
Notemigonus crysoleucas	Golden shiner
Ictaluridae	Freshwater catfishes
Ictalurus natalis	Yellow bullhead
Ictalurus nebulosus	Brown bullhead
Noturus gyrinus	Tadpole madtom
Ariidae	Sea catfishes
Arius felis	Sea catfish
Bagre marinus	Gafftopsail catfish
Batrachoididae	Toadfishes
Opsanus beta	Gulf toadfish
Opsanus pardus	Leopard toadfish
Porichthys porosissimus	Atlantic midshipman
Gobiesocidae	Clingfishes
Gobiesox strumosus	Skilletfish
Lophiidae	Goosefishes
Lophius americanus	Goosefish
Antennariidae	Frogfishes
Antennarius ocellatus	Ocellated frogfish
Histrio histrio	Sargassumfish
Ogcocephalidae	Batfishes
Halieutichthys aculeatus	Pancake batfish
Ogcocephalus radiatus	Polka-dot batfish
Bregmacerotidae	Codlets
Bregmaceros atlanticus	Antenna codlet
Gadidae	Codfishes
Urophycis floridanus	Southern hake
Ophidiidae	Cusk-eels and brotulas
Lepophidium jeannae	Mottled cusk-eel
Ogilbia cayorum	Key brotula
Ophidion beani	Longnose cusk-eel
Ophidion grayi	Blotched cusk-eel
Ophidion holbrooki	Bank cusk-eel
Ophidion welshi	Crested cusk-eel
Exocoetidae	Flyingfishes and halfbeaks
Cypselurus heterurus	Atlantic flyingfish
Hemiramphus brasiliensis	Ballyhoo
Hyporhamphus unifasciatus	Halfbeak
Belonidae	Needlefishes
Ablennes hians	Flat needlefish
Strongylura marina	Atlantic needlefish
Strongylura notata	Redfin needlefish
Strongylura timucu	Timucu
Tylosurus crocodilus	Houndfish

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 4 of 11)

Scientific name	Common name[a]
Cyprinodontidae	Killifishes
Adinia xenica	Diamond killifish
Cyprinodon variegatus	Sheepshead minnow
Floridichthys carpio	Goldspotted killifish
Fundulus chrysotus	Golden topminnow
Fundulus confluentus	Marsh killifish
Fundulus grandis	Gulf killifish
Fundulus seminolis	Seminole killifish
Fundulus similis	Longnose killifish
Jordanella floridae	Flagfish
Lucania parva	Rainwater killifish
Rivulus marmoratus	Rivulus
Poeciliidae	Livebearers
Gambusia affinis	Mosquitofish
Heterandria formosa	Least killifish
Poecilia latipinna	Sailfin molly
Atherinidae	Silversides
Atherinomorus stipes	Hardhead silverside
Membras martinica	Rough silverside
Menidia beryllina	Tidewater silverside
Holocentridae	Squirrelfishes
Holocentrus ascensionis	Squirrelfish
Holocentrus bullisi	Deepwater squirrelfish
Zeidae	Dories
Zenopsis ocellata	American john dory
Caproidae	Boarfishes
Antigonia capros	Deepbody boarfish
Regalecidae	Oarfishes
Regalecus glesne	Oarfish
Syngnathidae	Pipefishes and seahorses
Corythoichthys albirostris	Whitenose pipefish
Hippocampus erectus	Lined seahorse
Hippocampus zosterae	Dwarf seahorse
Micrognathus crinigerus	Fringed pipefish
Micrognathus crinitus	Insular pipefish
Oostethus lineatus	Opossum pipefish
Syngnathus elucens	Shortfin pipefish
Syngnathus floridae	Dusky pipefish
Syngnathus louisianae	Chain pipefish
Syngnathus scovelli	Gulf pipefish
Syngnathus springeri	Bull pipefish
Centropomidae	Snooks
Centropomus undecimalis	Snook
Serranidae	Sea basses
Centropristis melana	Southern sea bass
Centropristis ocyurus	Bank sea bass

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 5 of 11)

Scientific name	Common name[a]
Serranidae (continued)	
Centropristis striata	Black sea bass
Diplectrum formosum	Sand perch
Epinephelus adscensionis	Rock hind
Epinephelus cruentatus[c]	Graysby
Epinephelus drummondhayi	Speckled hind
Epinephelus fulvus[c]	Coney
Epinephelus guttatus	Red hind
Epinephelus itajara	Jewfish
Epinephelus morio	Red grouper
Epinephelus nigritus	Warsaw grouper
Hypoplectrus puella	Barred hamlet
Liopropoma eukrines	Wrasse bass
Mycteroperca bonaci	Black grouper
Mycteroperca microlepis	Gag
Mycteroperca phenax	Scamp
Mycteroperca venenosa	Yellowfin grouper
Serraniculus pumilio	Pygmy sea bass
Serranus phoebe	Tattler
Serranus subligarius	Belted sandfish
Grammistidae	Soap fishes
Rypticus bistrispinus	Freckled soapfish
Rypticus maculatus	Whitespotted soapfish
Centrarchidae	Sunfishes
Elassoma evergladei	Everglades pygmy sunfish
Lepomis gulosus	Warmouth
Lepomis macrochirus	Bluegill
Lepomis microlophus	Redear sunfish
Micropterus salmoides	Largemouth bass
Percidae	Perches
Etheostoma fusiforme	Swamp darter
Priacanthidae	Bigeyes
Priacanthus arenatus	Bigeye
Pristigenys alta	Short bigeye
Apogonidae	Cardinalfishes
Apogon aurolineatus	Bridle cardinalfish
Apogon pseudomaculatus	Twospot cardinalfish
Astrapogon alutus	Bronze cardinalfish
Phaeoptyx xenus	Sponge cardinalfish
Branchiostegidae	Tilefishes
Malacanthus plumieri	Sand tilefish
Pomatomidae	Bluefishes
Pomatomus saltatrix	Bluefish
Rachycentridae	Cobias
Rachycentron canadum	Cobia

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 6 of 11)

Scientific name	Common name[a]
Echeneidae	Remoras
Echeneis naucrates	Sharksucker
Remora remora	Remora
Carangidae	Jacks and pompanos
Caranx crysos	Blue runner
Caranx hippos	Crevalle jack
Caranx latus	Horse-eye jack
Chloroscombrus chrysurus	Atlantic bumper
Decapterus punctatus	Round scad
Elagatis bipinnulata	Rainbow runner
Hemicaranx amblyrhynchus	Bluntnose jack
Oligoplites saurus	Leatherjack
Selene vomer	Lookdown
Seriola dumerili	Greater amberjack
Seriola rivoliana	Almaco jack
Seriola zonata	Banded rudderfish
Trachinotus carolinus	Florida pompano
Trachinotus falcatus	Permit
Trachurus lathami	Rough scad
Vomer setapinnis	Atlantic moonfish
Coryphaenidae	Dolphins
Coryphaena hippurus	Dolphin
Lutjanidae	Snappers
Lutjanus apodus	Schoolmaster
Lutjanus campechanus	Red snapper
Lutjanus cyanopterus	Cubera snapper
Lutjanus griseus	Gray snapper
Lutjanus synagris	Lane snapper
Ocyurus chrysurus	Yellowtail snapper
Rhomboplites aurorubens	Vermilion snapper
Lobotidae	Tripletails
Lobotes surinamensis	Tripletail
Gerreidae	Mojarras
Diapterus olisthostomus	Irish pompano
Diapterus plumieri	Striped mojarra
Eucinostomus argenteus	Spotfin mojarra
Eucinostomus gula	Silver jenny
Pomadasyidae	Grunts
Anisotremus virginicus	Porkfish
Haemulon aurolineatum	Tomtate
Haemulon flavolineatum	French grunt
Haemulon plumieri	White grunt
Haemulon sciurus	Bluestriped grunt
Orthopristis chrysoptera	Pigfish

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area (Sheet 7 of 11)

Scientific name	Common name[a]
Sparidae	Porgies
Archosargus probatocephalus	Sheepshead
Calamus arctifrons	Grass Porgy
Calamus proridens	Littlehead porgy
Diplodus holbrooki	Spotted pinfish
Lagodon rhomboides	Pinfish
Pagrus sedecim	Red porgy
Sciaenidae	Drums
Bairdiella chrysoura	Silver perch
Cynoscion arenarius	Sand seatrout
Cynoscion nebulosus	Spotted seatrout
Equetus lanceolatus	Jackknife-fish
Equetus umbrosus	Cubbyu
Leiostomus xanthurus	Spot
Menticirrhus americanus	Southern kingfish
Menticirrhus saxatilis[d]	King whiting
Menticirrhus littoralis	Gulf kingfish
Micropogon undulatus	Atlantic croaker
Odontoscion dentex	Reef croaker
Pogonias cromis	Black drum
Sciaenops ocellata	Red drum
Mullidae	Goatfishes
Mullus auratus	Red goatfish
Pseudupeneus maculatus	Spotted goatfish
Kyphosidae	Sea chubs
Kyphosus sectatrix	Bermuda chub
Ephippidae	Spadefishes
Chaetodipterus faber	Atlantic spadefish
Pomacanthidae[e]	Angelfishes
Centropyge argi	Cherubfish
Holacanthus bermudensis	Blue angelfish
Holacanthus ciliaris	Queen angelfish
Pomacanthus arcuatus	Gray angelfish
Pomacanthus paru	French angelfish
Chaetodontidae	Butterflyfishes
Chaetodon capistratus	Foureye butterflyfish
Chaetodon ocellatus	Spotfin butterflyfish
Chaetodon sedentarius	Reef butterflyfish
Chaetodon striatus	Banded butterflyfish
Cichlidae	Cichlids
Tilapia melanotheron	Blackchin mouthbrooder
Pomacentridae	Damselfishes
Abudefduf saxatilis	Sergeant major
Chromis enchrysurus	Yellowtail reeffish
Chromis scotti	Purple reeffish

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 8 of 11)

Scientific name	Common name[a]
Pomacentridae (continued)	Damselfishes
Pomacentrus partitus	Bicolor damselfish
Pomacentrus variabilis	Cocoa damselfish
Labridae	Wrasses
Halichoeres bivittatus	Slippery Dick
Halichoeres caudalis	Painted wrasse
Hemipteronotus novacula	Pearly razorfish
Lachnolaimus maximus	Hogfish
Thalassoma bifasciatum	Bluehead
Scaridae	Parrotfishes
Nicholsina usta	Emerald parrotfish
Scarus croicensis	Striped parrotfish
Mugilidae	Mullets
Agonostomus monticola	Mountain mullet
Mugil cephalus	Striped mullet
Mugil curema	White mullet
Mugil trichodon	Fantail mullet
Sphyraenidae	Barracudas
Sphyraena barracuda	Great barracuda
Sphyraena borealis	Northern sennet
Polynemidae	Threadfins
Polydactylus octonemus	Atlantic threadfin
Opistognathidae	Jawfishes
Opistognathus aurifrons	Yellowhead jawfish
Opistognathus lonchurus	Moustache jawfish
Opistognathus macrognathus	Spotfin jawfish
Dactyloscopidae	Sand stargazers
Dactyloscopus tridigitatus	Sand stargazer
Uranoscopidae	Stargazers
Astroscopus y-graecum	Southern stargazer
Kathetostoma albigutta	Lacner stargazer
Clinidae	Clinids
Chaenopsis ocellata	Bluethroat pikeblenny
Emblemaria atlantica	Banner blenny
Emblemaria pandionis	Sailfin blenny
Paraclinus fasciatus	Banded blenny
Paraclinus marmoratus	Marbled blenny
Starksia ocellata	Checkered blenny
Blenniidae	Combtooth blennies
Blennius marmoreus	Seaweed blenny
Blennius nicholsi	Highfin blenny
Chasmodes bosquianus	Striped blenny
Chasmodes saburrae	Florida blenny
Hypleurochilus geminatus	Crested blenny
Hypsoblennius hentzi	Feather blenny

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 9 of 11)

Scientific name	Common name[a]
Callionymidae	Dragonets
Callionymus agassizi	Spotfin dragonet
Callionymus pauciradiatus	Spotted dragonet
Eleotridae	Sleepers
Dormitator maculatus	Fat sleeper
Gobiidae	Gobies
Bathygobius soporator	Frillfin goby
Coryphopterus punctipectophorus	Spotted goby
Evermannichthys spongicola	Sponge goby
Gobionellus boleosoma	Darter goby
Gobionellus hastatus	Sharptail goby
Gobiosoma bosci	Naked goby
Gobiosoma horsti	Yellowline goby
Gobiosoma longipala	Twoscale goby
Gobiosoma macrodon	Tiger goby
Gobiosoma oceanops	Neon goby
Gobiosoma robustum	Code goby
Ioglossus calliurus	Blue goby
Microgobius carri	Seminole goby
Microgobius gulosus	Clown goby
Microgobius thalassinus	Green goby
Microdesmidae	Wormfishes
Microdesmus sp.	Wormfish
Acanthuridae	Surgeonfishes
Acanthurus chirurgus	Doctorfish
Acanthurus coeruleus	Blue tang
Trichiuridae	Cutlassfishes
Trichiurus lepturus	Atlantic cutlassfish
Scombridae	Mackerels and tuna
Acanthocybium solanderi	Wahoo
Euthynnus alletteratus	Little tunny
Scomber japonicus	Chub mackerel
Scomberomorus cavalla	King mackerel
Scomberomorus maculatus	Spanish mackerel
Thunnus atlanticus	Blackfin tuna
Luvaridae	Louvars
Luvarus imperialis	Louvar
Istiophoridae	Billfishes
Istiophorus platypterus	Sailfish
Stromateidae	Butterfishes
Ariomma regulus	Spotted driftfish
Peprilus alepidotus	Harvestfish
Peprilus triacanthus	Butterfish
Scorpaenidae	Scorpionfishes
Helicolenus dactylopterus	Blackbelly rosefish
Scorpaena brasiliensis	Barbfish

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 10 of 11)

Scientific name	Common name[a]
Scorpaenidae (continued)	
Scorpaena calcarata	Smoothhead scorpionfish
Scorpaena plumieri	Spotted scorpionfish
Triglidae	Searobins
Bellator militaris	Horned searobin
Prionotus martis	Barred searobin
Prionotus ophryas	Bandtail searobin
Prionotus roseus	Bluespotted searobin
Prionotus rubio	Blackfin searobin
Prionotus salmonicolor	Blackwing searobin
Prionotus scitulus	Leopard searobin
Prionotus tribulus	Bighead searobin
Bothidae	Lefteye flounders
Ancylopsetta quadrocellata	Ocellated flounder
Bothus ocellatus	Eyed flounder
Bothus robinsi	Flounder
Citharichthys macrops	Spotted whiff
Cyclopsetta fimbriata	Spotfin flounder
Etropus crossotus	Fringed flounder
Etropus rimosus	Gray flounder
Paralichthys albigutta	Gulf flounder
Paralichthys lethostigma	Southern flounder
Paralichthys squamilentus	Broad flounder
Syacium papillosum	Dusky flounder
Soleidae	Soles
Achirus lineatus	Lined sole
Gymnachirus melas	Naked sole
Gymnachirus sp.	Sole
Trinectes maculatus	Hogchoker
Cynoglossidae	Tonguefishes
Symphurus diomedianus	Spottedfin tonguefish
Symphurus minor	Largescale tonguefish
Symphurus plagiusa	Blackcheek tonguefish
Symphurus urospilus	Spottail tonguefish
Triacanthodidae	Spikefishes
Parahollardia lineata	Jambeau
Balistidae	Triggerfishes and filefishes
Aluterus heudeloti	Dotterel filefish
Aluterus schoepfi	Orange filefish
Balistes capriscus	Gray triggerfish
Balistes vetula	Queen triggerfish
Monacanthus ciliatus	Fringed filefish
Monacanthus hispidus	Planehead filefish

Note: See footnotes at end of table.

Table 2-38. Fishes reported from the Tampa Bay area
(Sheet 11 of 11)

Scientific name	Common name[a]
Ostraciidae	Boxfishes
Lactophrys quadricornis	Scrawled cowfish
Lactophrys trigonus	Trunkfish
Lactophrys triqueter	Smooth trunkfish
Tetraodontidae	Puffers
Canthigaster rostrata	Sharpnose puffer
Lagocephalus laevigatus	Smooth puffer
Sphoeroides dorsalis	Marbled puffer
Sphoeroides nephelus	Southern puffer
Sphoeroides spengleri	Bandtail puffer
Diodontidae	Porcupinefishes
Chilomycterus schoepfi	Striped burrfish
Diodon holocanthus	Balloonfish

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[a] Common names after Bailey et al. (1970).
[b] Formerly *H. pensacolae* (Whitehead 1973).
[c] *E. cruentatus*, *E. fulvus* after Smith (1971).
[d] Formerly *M. focaliger* (Irwin 1970; Hoese and Moore 1977).
[e] Extraction of Pomacanthidae from Chaetodontidae after Burgess (1974).

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 1 of 12)

Taxon	Occurrence	
	Tampa Bay[a]	Gulf of Mexico[b]
Orectolobidae		
Ginglymostoma cirratum	X	X
Rhincodontidae		
Rhincodon typus		X
Odontaspididae		
Odontaspis taurus	X	X
Lamnidae		
Carcharodon carcharias	X	
Isurus oxyrinchus		X
Carcharhinidae		
Carcharhinus acronotus	X	X
Carcharhinus leucas	X	X
Carcharhinus limbatus	X	X
Carcharhinus milberti	X	X
Carcharhinus obscurus	X	
Galeocerdo cuvieri		X
Mustelus canis	X	
Mustelus norrisi	X	X
Negaprion brevirostris		X
Rhizoprionodon terraenovae	X	
Sphyrnidae		
Sphyrna lewini		X
Sphyrna mokarran	X	X
Sphyrna tiburo	X	X
Pristidae		
Pristis pectinata	X	
Pristis perotteti		X
Rhinobatidae		
Rhinobatos lentiginosus	X	X
Torpedinidae		
Narcine brasiliensis		X
Rajidae		
Raja eglanteria	X	X
Raja texana		X
Dasyatidae		
Dasyatis americana	X	
Dasyatis sabina	X	
Dasyatis sayi		X
Gymnura micrura	X	X
Myliobatidae		
Aetobatus narinari	X	X
Rhinoptera bonasus	X	
Mobulidae		
Manta birostris	X	X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 2 of 12)

Taxon	Occurrence	
	Tampa Bay[a]	Gulf of Mexico[b]
Acipenseridae		
Acipenser oxyrhynchus	X[d]	
Lepisosteidae		
Lepisosteus osseus	X[c]	
Lepisosteus platyrhincus	X[c]	
Elopidae		
Elops saurus	X[d]	X
Megalops atlantica	X[d]	X
Albulidae		
Albula vulpes	X	
Anguillidae		
Anguilla rostrata	X[c]	
Muraenidae		
Gymnothorax moringa		X[g]
Gymnothorax nigromarginatus	X	X
Gymnothorax sp.	X	X
Congridae		
Conger oceanicus		X
Ophichthidae		
Ahlia egmontis		X
Bascanichthys scuticaris		X
Bascanichthys teres	X	X
Letharchus velifer		X
Myrophis punctatus	X	X
Mystriophis intertinctus	X	X
Mystriophis mordax		X
Mystriophis punctifer	X	
Ophichthus gomesi	X	X
Ophichthus ocellatus	X	X
Clupeidae		
Brevoortia patronus	X	X
Brevoortia smithi	X	
Dorosoma cepedianum	X[c]	
Dorosoma petenense	X[c]	
Etrumeus teres		X
Harengula jajuana	X[d]	X
Opisthonema oglinum	X[d]	X
Sardinella anchovia	X	X
Sardinella brasiliensis		X
Engraulidae		
Anchoa cubana	X	X
Anchoa hepsetus	X	X
Anchoa mitchilli	X[d]	X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area (Sheet 3 of 12)

Taxon	Occurrence: Tampa Bay[a]	Occurrence: Gulf of Mexico[b]
Synodontidae		
Saurida brasiliensis		X
Saurida normani		X
Synodus foetens	X	X
Synodus intermedius	X	X
Trachinocephalus myops		X
Cyprinidae		
Notemigonus crysoleucas	X[c]	
Ictaluridae		
Ictalurus natalis	X[c]	
Ictalurus nebulosus	X[c]	
Noturus gyrinus	X[c]	
Ariidae		
Arius felis	X[d]	X
Bagre marinus	X	X
Batrachoididae		
Opsanus beta	X	X
Opsanus pardus		X[g]
Porichthys porosissimus	X	X
Gobiesocidae		
Gobiesox strumosus	X	X
Lophiidae		
Lophius americanus		X
Antennariidae		
Antennarius ocellatus	X	X[g]
Antennarius radiosus		
Histrio histrio		X
Ogcocephalidae		
Halieutichthys aculeatus	X	X
Ogcocephalus radiatus	X	X
Ogcocephalus sp.	X	X
Bregmacerotidae		
Bregmaceros atlanticus		X
Gadidae		
Urophycis floridanus	X	X
Ophidiidae		
Lepophidium jeannae		X
Ogilbia cayorum		X[g]
Ophidion beani	X	X
Ophidion grayi	X	X
Ophidion holbrooki	X	X
Ophidion welshi	X	X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 4 of 12)

Taxon	Occurrence	
	Tampa Bay[a]	Gulf of Mexico[b]
Exocoetidae		
Cypselurus heterurus		X
Cypselurus sp.	X	X
Hemiramphus brasiliensis		X
Hyporhamphus unifasciatus	X	X
Belonidae		
Ablennes hians		X
Strongylura marina	X[d]	X
Strongylura notata	X	X
Strongylura timucu	X	X
Tylosurus crocodilus	X	X
Cyprinodontidae		
Adinia xenica	X	
Cyprinodon variegatus	X[d]	
Floridichthys carpio	X	
Fundulus chrysotus	X[e]	
Fundulus confluentus	X	
Fundulus grandis	X	
Fundulus seminolis	X[e]	
Fundulus similis	X	
Jordanella floridae	X[e]	
Lucania parva	X	
Rivulus marmoratus	X[c]	
Poeciliidae		
Gambusia affinis	X[c]	
Heterandria formosa	X[c]	
Poecilia latipinna	X[c]	
Atherinidae		
Atherinomorus stipes	X	
Membras martinica	X	X
Menidia beryllina	X[d]	X
Holocentridae		
Holocentrus ascensionis		X[g]
Holocentrus bullisi		X
Zeidae		
Zenopsis ocellata		X
Caproidae		
Antigonia capros		X
Regalecidae		
Regalecus glesne		X
Syngnathidae		
Corythoichthys albirostris	X	X
Hippocampus erectus	X	X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area (Sheet 5 of 12)

Taxon	Occurrence Tampa Bay[a]	 Gulf of Mexico[b]
Syngnathidae (continued)		
Hippocampus zosterae	X	X
Hippocampus sp.	X	X
Micrognathus crinigerus	X	
Micrognathus crinitus	X	
Oostethus lineatus	X	
Syngnathus elucens		X
Syngnathus floridae	X	X
Syngnathus louisianae	X	X
Syngnathus scovelli	X[d]	X
Syngnathus springeri		X
Centropomidae		
Centropomus undecimalis	X[d]	X
Serranidae		
Centropristis melana	X	X[g]
Centropristis ocyurus		X[g]
Centropristis striata		X
Diplectrum formosum	X	X
Epinephelus adscensionis		X[g]
Epinephelus cruentatus		X[g]
Epinephelus drummondhayi		X[g]
Epinephelus fulvus		X[g]
Epinephelus guttatus		X[g]
Epinephelus itajara	X	X[g]
Epinephelus morio	X	X[g]
Epinephelus nigritus		X[g]
Hypoplectrus puella		X[g]
Liopropoma eukrines		X
Mycteroperca bonaci		X[g]
Mycteroperca microlepis	X	X[g]
Mycteroperca phenax		X[g]
Mycteroperca venenosa		X
Serraniculus pumilio	X	X
Serranus phoebe		X
Serranus subligarius	X	X[g]
Grammistidae		
Rypticus bistrispinus		X
Rypticus maculatus		X[g]
Centrarchidae		
Elassoma evergladei	X[e]	
Lepomis gulosus	X[c]	
Lepomis macrochirus	X[c]	
Lepomis microlophus	X[c]	
Micropterus salmoides	X[c]	

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 6 of 12)

Taxon	Occurrence	
	Tampa Bay[a]	Gulf of Mexico[b]
Percidae		
Etheostoma fusiforme	X[e]	
Priacanthidae		
Priacanthus arenatus		X[g]
Pristigenys alta		X[g]
Apogonidae		
Apogon aurolineatus		X[g]
Apogon pseudomaculatus		X[g]
Astrapogon alutus	X	X[g]
Phaeoptyx xenus		X[g]
Branchiostegidae		
Malacanthus plumieri		X
Pomatomidae		
Pomatomus saltatrix	X	X
Rachycentridae		
Rachycentron canadum	X	X
Echeneidae		
Echeneis naucrates	X	X
Remora remora	X	X
Carangidae		
Caranx crysos	X	X
Caranx hippos	X	
Caranx latus	X	
Chloroscombrus chrysurus	X	X
Decapterus punctatus	X	X
Elagatis bipinnulata		X
Hemicaranx amblyrhynchus	X	
Oligoplites saurus	X	X
Selene vomer	X	X
Seriola dumerili		X
Seriola rivoliana		X
Seriola zonata	X	X
Trachinotus carolinus	X	X
Trachinotus falcatus	X	X
Trachurus lathami		X[g]
Vomer setapinnis	X	
Coryphaenidae		
Coryphaena hippurus		X
Lutjanidae		
Lutjanus apodus	X	X
Lutjanus campechanus		X[g]
Lutjanus cyanopterus		X[g]
Lutjanus griseus	X[d]	X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 7 of 12)

Taxon	Occurrence	
	Tampa Bay[a]	Gulf of Mexico[b]
Lutjanidae (continued)		
Lutjanus synagris	X	X
Ocyurus chrysurus		X[g]
Rhomboplites aurorubens		X[g]
Lobotidae		
Lobotes surinamensis	X	
Gerreidae		
Diapterus olisthostomus	X	
Diapterus plumieri	X[d]	
Eucinostomus argenteus	X[d]	X
Eucinostomus gula	X	X
Pomadasyidae		
Anisotremus virginicus		X
Haemulon aurolineatum	X	X[g]
Haemulon flavolineatum	X	
Haemulon plumieri	X	X[g]
Haemulon sciurus	X	
Orthopristis chrysoptera	X[d]	X
Sparidae		
Archosargus probatocephalus	X[d]	X
Calamus arctifrons	X	X
Calamus proridens		X[g]
Diplodus holbrooki	X	X
Lagodon rhomboides	X[d]	X
Pagrus sedecim		X[g]
Sciaenidae		
Bairdiella chrysoura	X[d]	X
Cynoscion arenarius	X[d]	X
Cynoscion nebulosus	X[d]	X
Equetus lanceolatus		X[g]
Equetus umbrosus	X	X[g]
Leiostomus xanthurus	X[d]	X
Menticirrhus americanus	X	X
Menticirrhus saxatilis[f]	X	X
Menticirrhus littoralis		X
Micropogon undulatus	X[d]	X
Odontoscion dentex		X[g]
Pogonias cromis	X	X
Sciaenops ocellata	X[d]	X
Mullidae		
Mullus auratus		X
Pseudupeneus maculatus	X	X[g]
Kyphosidae		
Kyphosus sectatrix	X	

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 8 of 12)

Taxon	Occurrence	
	Tampa Bay[a]	Gulf of Mexico[b]
Ephippidae		
Chaetodipterus faber	X	X
Pomacanthidae		
Centropyge argi		X[g]
Holacanthus bermudensis		X[g]
Holacanthus ciliaris	X	X[g]
Pomacanthus arcuatus		X[g]
Pomacanthus paru		X[g]
Chaetodontidae		
Chaetodon capistratus		X[g]
Chaetodon ocellatus		X[g]
Chaetodon sedentarius		X[g]
Chaetodon striatus		X[g]
Cichlidae		
Tilapia melanotheron	X[h]	
Pomacentridae		
Abudefdu saxatilis		X[g]
Chromis enchrysurus		X[g]
Chromis scotti		X[g]
Pomacentrus partitus		X[g]
Pomacentrus variabilis		X[g]
Labridae		
Halichoeres bivittatus	X	X[g]
Halichoeres caudalis		X[g]
Hemipteronotus novacula		X
Lachnolaimus maximus	X	X[g]
Thalassoma bifasciatum		X[g]
Scaridae		
Nicholsina usta	X	X
Scarus croicensis		X[g]
Mugilidae		
Agonostomus monticola	X[c]	
Mugil cephalus	X[d]	X
Mugil curema	X[d]	X
Mugil trichodon	X	X
Sphyraenidae		
Sphyraena barracuda	X	X[g]
Sphyraena borealis	X	X
Polynemidae		
Polydactylus octonemus	X	X
Opistognathidae		
Opistognathus aurifrons		X[g]
Opistognathus lonchurus		X
Opistognathus macrognathus	X	X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 9 of 12)

Taxon	Occurrence	
	Tampa Bay[a]	Gulf of Mexico[b]
Dactyloscopidae		
Dactyloscopus tridigitatus	X	
Uranoscopidae		
Astroscopus y-graecum	X	X
Kathetostoma albigutta		X
Clinidae		
Chaenopsis ocellata		X[g]
Emblemaria atlantica		X[g]
Emblemaria pandionis		X[g]
Paraclinus fasciatus	X	
Paraclinus marmoratus	X	
Starksia ocellata		X[g]
Blenniidae		
Blennius marmoreus	X	X[g]
Blennius nicholsi		X
Chasmodes bosquianus	X	
Chasmodes saburrae	X	
Hypleurochilus geminatus	X	X
Hypsoblennius hentzi	X	
Callionymidae		
Callionymus agassizi		X
Callionymus pauciradiatus		X[g]
Eleotridae		
Dormitator maculatus	X[d]	
Gobiidae		
Bathygobius soporator	X	X
Coryphopterus punctipectophorus		X[g]
Evermannichthys spongicola		X
Gobionellus boleosoma	X[d]	
Gobionellus hastatus	X	
Gobiosoma bosci	X[d]	
Gobiosoma horsti		X[g]
Gobiosoma longipala	X	
Gobiosoma macrodon	X	X
Gobiosoma oceanops		X[g]
Gobiosoma robustum	X[d]	
Ioglossus calliurus		X
Microgobius carri		X[g]
Microgobius gulosus	X[d]	
Microgobius thalassinus	X[d]	
Microdesmidae		
Microdesmus sp.		X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 10 of 12)

Taxon	Occurrence Tampa Bay[a]	 Gulf of Mexico[b]
Acanthuridae		
Acanthurus chirurgus		X[g]
Acanthurus coeruleus		X[g]
Trichiuridae		
Trichiurus lepturus	X	X
Scombridae		
Acanthocybium solanderi		X
Euthynnus alletteratus		X
Scomber japonicus	X	X
Scomberomorus cavalla	X	X
Scomberomorus maculatus	X	X
Thunnus atlanticus		X
Luvaridae		
Luvarus imperialis		X
Istiophoridae		
Istiophorus platypterus		X
Stromateidae		
Ariomma regulus		X
Peprilus alepidotus	X	X
Peprilus triacanthus	X	X
Scorpaenidae		
Helicolenus dactylopterus		X
Scorpaena brasiliensis	X	X
Scorpaena calcarata	X	X
Scorpaena plumieri		X[g]
Triglidae		
Bellator militaris		X
Prionotus martis		X
Prionotus ophryas	X	X
Prionotus roseus	X	X
Prionotus rubio	X	
Prionotus salmonicolor		X
Prionotus scitulus	X	X
Prionotus tribulus	X	X
Bothidae		
Ancylopsetta quadrocellata	X	X
Bothus ocellatus		X
Bothus robinsi		X
Citharichthys macrops	X	X
Cyclopsetta fimbriata		X
Etropus crossotus	X	X
Etropus rimosus		X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area (Sheet 11 of 12)

Taxon	Occurrence	
	Tampa Bay[a]	Gulf of Mexico[b]
Bothidae (continued)		
Paralichthys albigutta	X	X
Paralichthys lethostigma	X[d]	
Paralichthys squamilentus		X
Syacium papillosum	X	X
Soleidae		
Achirus lineatus	X[d]	X
Gymnachirus melas		X
Gymnachirus sp.	X	
Trinectes maculatus	X[d]	
Cynoglossidae		
Symphurus diomedianus		X
Symphurus minor		X
Symphurus plagiusa	X	X
Symphurus urospilus		X
Triacanthodidae		
Parahollardia lineata		X
Balistidae		
Aluterus heudeloti		X
Aluterus schoepfi	X	X
Balistes capriscus		X[g]
Balistes vetula		X[g]
Monacanthus ciliatus	X	X
Monacanthus hispidus	X	X
Ostraciidae		
Lactophrys quadricornis	X	X
Lactophrys trigonus	X	
Lactophrys triqueter	X	
Tetraodontidae		
Canthigaster rostrata		X[g]
Lagocephalus laevigatus	X	X
Sphoeroides dorsalis		X
Sphoeroides nephelus	X	X
Sphoeroides spengleri		X[g]
Diodontidae		
Chilomycterus schoepfi	X	X
Diodon holocanthus	X	X

Note: See footnotes and note at end of table.

Table 2-39. Occurrence of fishes in the Tampa Bay area
(Sheet 12 of 12)

[a] Reported from within Tampa Bay and adjacent estuarine systems, including freshwater tributaries (Springer and Woodburn 1960; Springer 1961; Finucane 1966b; Sykes and Finucane 1966; Humm et al. 1971; Baird et al. 1972, 1973, 1975; Powell, Dwinell, and Dwinell 1972; Florida Committee on Rare and Endangered Plants and Animals 1976).

[b] Reported from Gulf of Mexico waters, including rocky reefs, offshore of Tampa Bay (Springer and Woodburn 1960; Moe 1963; Moe and Martin 1965; Powell, Dwinell, and Dwinell 1972; Smith 1976).

[c] Predominantly freshwater species, occasionally found in marine waters.

[d] Marine species, occasionally found in freshwater tributaries.

[e] Freshwater species.

[f] Formerly M. focaliger (Irwin 1970; Hoese and Moore 1977).

[g] Considered primary offshore reef species (Smith 1976) or reported in Tampa Bay area only from local reefs.

[h] Freshwater species introduced into Hillsborough Bay area and now thriving there (Springer and Finucane 1963).

Note: Footnotes c, d, e, and f adapted from Bailey et al. (1970), Florida Committee on Rare and Endangered Plants and Animals (1976), and Hoese and Moore (1977).

Table 2-40. Fish species occurring in 1 percent or more of beach seine and trawl collections in Tampa Bay, 1961-1964[a]

Species[b]	Common name	Beach seine	Trawl
Anchoa mitchilli	Bay anchovy	X	X
Menidia beryllina	Tidewater silverside	X	--
Leiostomus xanthurus	Spot	X	X
Lagodon rhomboides	Pinfish	X	X
Bairdiella chrysoura	Silver perch	X	X
Eucinostomus gula	Silver jenny	X	X
Mugil cephalus	Striped mullet	X	--
Fundulus similis	Longnose killifish	X	--
Cyprinodon variegatus	Sheepshead killifish	X	--
Eucinostomus argenteus	Spotfin mojarra	X	--
Lucania parva	Rainwater killifish	X	--
Harengula jaguana[c]	Scaled sardine	X	--
Floridichthys carpio	Goldspotted killifish	X	--
Fundulus grandis	Gulf killifish	X	--
Membras martinica	Rough silverside	X	--

[a] Adapted from Finucane (1966b).
[b] Listed in order of greatest abundance for all collections.
[c] Formerly *H. pensacolae* (Whitehead 1973).

Table 2-41. Seasonal occurrence of dominant young-of-year fish in Tampa Bay, 1961-1964[a]

Winter and spring	Summer	Fall
Mugil cephalus (Striped mullet)	*Bairdiella chrysoura* (Silver perch)	*Anchoa mitchilli* (Bay anchovy)
Leiostomus xanthurus (Spot)	*Menidia beryllina* (Tidewater silversides)	*Mugil trichodon* (Silver mullet)
Lagodon rhomboides (Pinfish)	*Cynoscion nebulosus* (Sand sea trout)	*Chloroscombrus chrysurus* (Bumper)
Anchoa mitchilli (Bay anchovy)	*Cynoscion arenarius* (Spotted sea trout)	*Menidia beryllina* (Tidewater silversides)
Bairdiella chrysoura (Silver perch)	*Orthopristis chrysopterus* (Pigfish)	*Sciaenops ocellata* (Redfish)
Menidia beryllina (Tidewater silversides)	*Diapterus plumieri* (Striped mojarra)	*Bairdiella chrysoura* (Silver perch)
--	--	*Cyprinodon variegatus* (Sheepshead minnow)
--	--	*Fundulus similis* (Longnose killifish)
--	--	*Fundulus grandis* (Gulf killifish)

[a] Adapted from Finucane (1966b).

Table 2-42. List of fishes killed by red tide and found floating in a boat basin in Boca Ciega Bay, Pinellas County, Florida, October 3, 1957[a]

Species	Approximate number
Harengula jaguana[b]	100s
Lagodon rhomboides	100s
Brevoortia sp.	100s
Mugil cephalus	100
Arius felis	50
Ophichthus gomesi	50
Leiostomus xanthurus	50
Cynoscion nebulosus	50
Archosargus probatocephalus	50
Orthopristis chrysopterus	30
Eucinostomus argenteus	30
Chaetodipterus faber	10
Paralichthys sp.	3
Balistes capriscus	1
Monacanthus hispidus	1
Strongylura sp.	1
Trinectes maculatus	1
Synodus foetens	1
Diapterus plumieri	1
Gymnothorax sp.	1
Caranx sp.	1
Scomberomorus sp.	1

[a] Adapted from Springer and Woodburn (1960).

[b] Formerly H. pensacolae (Whitehead 1973).

Table 2-43. List of fishes killed by red tide and found on a 1,030-foot stretch of uncleared Gulf of Mexico beach just north of Madeira Beach, Pinellas County, Florida, October 3, 1957[a]

Species	Approximate number of specimens
Opisthonema oglinum	800
Haemulon plumieri	500
Mugil cephalus	250
Brevoortia sp.	200
Bairdiella chrysoura	100
Bagre marinus	100
Orthopristis chrysopterus	100
Leiostomus xanthurus	80
Ophichthus gomesi	80
Cynoscion nebulosus	50
Cynoscion arenarius	50
Menticirrhus sp.	50
Opsanus beta	50
Anchoa hepsetus	30
Prionotus scitulus	30
Epinephelus morio	25
Lagodon rhomboides	20
Arius felis	20
Chilomycterus schoepfi	15
Strongylura notata	6
Elops saurus	6
Lactophrys quadricornis	5
Synodus foetens	5
Symphurus plagiusa	5
Astroscopus y-graecum	5
Sphoeroides nephelus	4
Chaetodipterus faber	3
Archosargus probatocephalus	2
Rypticus maculatus	2
Gymnothorax sp.	2
Trachinotus carolinus	2
Calamus arctifrons	2
Pogonias cromis	2
Scorpaena sp.	2
Paralichthys sp.	2
Abudefduf saxatilis	1
Monacanthus hispidus	1
Centropomus undecimalis	1
Ophidion holbrooki	1
Centropristes sp.	1
Caranx crysos	1
Mystriophis mordax	1
Strongylura timucu	1
Hyporhamphus unifasciatus	1

[a] Adapted from Springer and Woodburn (1960).

Table 2-44. Aquatic mammals (orders Sirenia and Cetacea) whose geographic ranges include Tampa Bay and adjacent waters of the Gulf of Mexico[a]

		Status	
Common name	Scientific name	Federal[b]	FGFWFC
	Sirenia		
Florida (West Indian) manatee	*Trichechus manatus*	E	E
	Cetacea		
Tropical beaked whale	*Mesoplodon densirostris*		
Gervais' beaked whale	*Mesoplodon europaeus*		
True's beaked whale	*Mesoplodon mirus*		
Goose-beaked whale	*Ziphius cavirostris*		
Sperm whale	*Physeter catodon*	E	E
Pygmy sperm whale	*Kogia breviceps*		
Spotted porpoise	*Stenella dubia*		
Long-beaked porpoise	*Stenella longirostris*		
Striped porpoise	*Stenella caeruleoalba*		
Rough-toothed porpoise	*Steno bredanensis*		
Common or saddle-backed porpoise	*Delphinus delphis*		
Bottle-nosed dolphin	*Tursiops truncatus*		
Grampus or Risso's dolphin	*Grampus griseus*		
False killer whale	*Pseudorca crassidens*		
Short-finned pilot whale	*Globicephala macrorhyncha*		
Fin whale	*Balaenoptera physalus*	E	E
Sei whale or rorqual	*Balaenoptera borealis*	E	E
Little piked whale	*Balaenoptera acutorostrata*		
Blue or sulphur-bottomed whale	*Balaenoptera musculus*	E	E
Hump-backed whale	*Megaptera novaeangliae*	E	E
Right whale	*Balaena glacialis*	E	

Abbreviations:
FGFWFC = Florida Game and Fresh Water Fish Commission (1979).
E = endangered.

[a] List compiled from Hall and Kelson (1959), Burt and Grossenheider (1976), Layne et al. (1977), and Layne (1978). Only the manatee and the bottle-nosed dolphin occur in Tampa Bay with any regularity; other species could occur offshore in the Gulf of Mexico.

[b] From 44 FR 12, 3,636 - 3,654.

Table 2-45. Commercial catch data for fishes landed in the Tampa Bay area (Pinellas, Hillsborough, and Manatee Counties combined) and along the entire Florida west coast from 1966 to 1976[a]

Year	Tampa Bay area		Florida west coast	
	Catch weight (lb)	Ex-vessel value (dollars)	Catch weight (lb)	Ex-vessel value (dollars)
1966	15,575,664	1,878,940	71,696,238	8,084,744
1967	14,049,398	1,727,486	68,226,785	7,851,943
1968	11,555,761	1,621,331	71,750,380	8,727,584
1969	14,743,187	2,168,240	70,320,361	10,115,422
1970	12,305,301	1,949,677	61,817,776	10,217,440
1971	12,818,243	2,073,756	63,203,994	10,418,189
1972	12,472,978	2,396,444	63,965,476	11,895,266
1973	11,386,954	2,303,526	66,503,352	13,536,154
1974	13,062,432	3,577,585	72,644,104	17,314,984
1975	12,544,954	3,747,920	64,821,730	16,896,990
1976	10,170,488	3,688,998	60,411,186	18,606,586

[a] Adapted from State of Florida Board of Conservation (1967, 1968, 1970) and Florida Department of Natural Resources (1970 through 1977).

Table 2-46. Commercial catch data for important invertebrates landed in the Tampa Bay area (Pinellas, Hillsborough, and Manatee Counties combined) from 1966 to 1976[a]

Year	Bait shrimp			Adult shrimp (taken on central Florida west coast)		Stone crab		Blue crab	
	Number of individuals	Catch weight (lb)	Ex-vessel value (dollars)	Catch weight (lb)	Ex-vessel value (dollars)	Catch weight (lb)	Ex-vessel value (dollars)	Catch weight (lb)	Ex-vessel value (dollars)
1966	22,987,030	ND	278,114	699,123	328,609	24,610	7,084	2,285,012	135,983
1967	22,916,521	ND	294,168	586,322	260,113	13,976	5,272	758,959	50,224
1968	21,940,350	ND	279,750	285,929	120,509	21,687	10,883	238,359	18,678
1969	25,175,900	ND	329,626	696,222	410,259	78,558	44,515	199,573	23,756
1970	22,819,550	ND	293,681	606,541	317,699	60,282	31,866	437,412	33,576
1971	15,699,600	ND	202,212	446,683	275,315	23,218	12,064	274,117	23,710
1972	15,215,504	ND	191,012	768,923	727,106	24,911	14,937	341,866	30,648
1973	13,873,950	ND	193,779	-	-	64,060	47,593	69,613	12,260
1974	15,923,515	ND	229,060	1,321,233	1,001,988	26,131	21,279	61,136	13,598
1975	11,342,700	141,785	184,551	2,264,677	2,428,757	51,788	48,332	820,000	122,571
1976	ND	131,892	188,661	1,926,603	2,391,382	190,408	168,014	233,441	48,153

Abbreviation: ND = no data.

[a] Adapted from State of Florida Board of Conservation (1967, 1968, 1970) and Florida Department of Natural Resources (1970 through 1977).

Table 2-47. Commercial fishery data for the catch landed in the Tampa Bay area (Pinellas, Hillsborough, and Manatee Counties combined) during 1976[a] (Sheet 1 of 2)

Taxon	Catch weight (lb)	Ex-vessel value (dollars)
Fishes		
Alewives	1,500	150
Amberjack	18,084	2,074
Angelfish	4,569	920
Ballyhoo	874	305
Barracuda	559	23
Blue runner	472	35
Bluefish	33,367	4,745
Bonito	2,931	138
Catfish, freshwater	13,359	5,076
Catfish, sea	410	16
Cigarfish	950	142
Cobia	2,579	515
Crevalle jacks	406,977	30,659
Croaker	63,519	15,873
Dolphin	621	136
Drum, black	11,876	851
Drum, red	131,950	31,970
Flounders	4,622	1,506
Groupers and scamp	3,030,175	1,456,175
Grunts	104,881	20,433
Herring, thread	21,760	1,522
Hogfish	1,940	953
Jewfish	9,434	1,646
King mackerel	112,517	40,141
King whiting	9,683	2,512
Menhaden	2,217	388
Mullet, black (striped)	3,422,439	592,382
Mullet, silver	13,054	1,489
Permit	92,683	20,402
Pigfish	3,621	212
Pompano	72,862	98,647
Sand perch (mojarra)	47,874	8,341
Scup	20,658	4,275
Sea bass	29,438	6,057
Seatrout, spotted	286,788	125,994
Seatrout, sand	2,884	539
Shad	592	27
Sharks	5,792	672
Sheepshead	42,194	6,649
Snapper, lane	54	27
Snapper, mangrove	21,877	10,745

Note: See footnote at end of table.

Table 2-47. Commercial fishery data for the catch landed in the Tampa Bay area (Pinellas, Hillsborough, and Manatee Counties combined) during 1976[a] (Sheet 2 of 2)

Taxon	Catch weight (lb)	Ex-vessel value (dollars)
Fishes (continued)		
Snapper, mutton	8,424	5,040
Snapper, red	1,034,468	1,029,630
Snapper, vermilion	12,435	8,823
Snapper, yellowtail	902	674
Spanish mackerel	162,580	31,172
Spanish sardines	490,765	49,393
Spot	9,232	1,403
Swordfish	1,586	3,092
Ten pounder (ladyfish)	29,964	1,297
Tilapia (nile perch)	4,964	998
Tilefish	31,764	9,234
Triggerfish	3,210	393
Wahoo	51	15
Warsaw	78,533	21,470
Unclassified: for food	198,537	29,720
Unclassified: for miscellaneous	48,437	2,077
Total fish	10,170,488	3,688,998
Invertebrates		
Crabs, blue	233,441	48,153
Crabs, stone	190,408	168,014
Lobster, spiny	231	439
Scallops, bay	1,054	2,367
Shrimp, bait	131,892	188,661
Shrimp, central west coast	1,926,603	2,391,382
Shrimp, rock	657,397	354,375
Sponges, glove	14	253
Sponges, grass	18	221
Sponges, sheepswool	1,319	25,203
Sponges, yellow	98	826
Squid	14,780	3,844
Total invertebrates	3,157,255	3,183,738

[a] Adapted from Florida Department of Natural Resources (1977).

Table 2-48. Fishes and invertebrates that are important in Gulf of Mexico fisheries and inhabit the Tampa Bay system in early developmental stages[a]

Scientific name	Common name[b]
Fishes	
Brevoortia patronus	Gulf menhaden
Brevoortia smithi	Yellowfin menhaden
Epinephelus morio	Red grouper
Mycteroperca microlepsis	Gag
Caranx hippos	Crevalle jack
Trachinotus carolinus	Florida pompano
Trachinotus sp.	Permit
Diapterus plumieri	Striped mojarra
Eucinostomus argenteus	Spotfin mojarra
Eucinostomus gula	Silver jenny
Archosargus probatocephalus	Sheepshead
Cynoscion arenarius	Sand seatrout
Cynoscion nebulosus	Spotted seatrout
Leiostomus xanthurus	Spot
Pogonias cromis	Black drum
Sciaenops ocellata	Red drum
Mugil cephalus	Striped mullet
Mugil curema	White mullet
Mugil trichodon	Fantail mullet
Scomberomorus maculatus	Spanish mackerel
Invertebrates	
Crassostrea virginica	Eastern oyster
Penaeus duorarum	Pink shrimp
Callinectes sapidus	Blue crab

[a] Adapted from Sykes and Finucane (1966).

[b] Common names of fishes after Bailey et al. (1970).

Table 2-49. Area of oyster beds (public and private) and area closed to shellfishing by state and county governments in the Tampa Bay system[a]

Subarea	Surface area (acres): Public: Natural	Public: Planted	Private[b]	Closed to shellfishing
Old Tampa Bay	10	3	1,097	8,202
Hillsborough Bay	0	0	0	28,900
Tampa Bay	250	0	7	0
Boca Ciega Bay	0	0	0	29,648
Total	260	3	1,104	66,750

[a]Adapted from McNulty, Lindall, and Sykes (1972).
[b]Leased from state.

Table 2-50. Results of a survey of pier fishermen in Pinellas County conducted by the National Marine Fisheries Service to determine the composition and seasonal distribution of local sports fishes[a]

Common name	Season of high catches
Snook	Summer
Silver perch	Winter and spring
Sheepshead	Winter and spring
Spotted seatrout	Spring
Atlantic croaker	Spring
Grunt	Spring
Spanish mackerel	Summer, fall, winter, and spring
Crevalle jack	Summer, fall, and winter
Gulf flounder	Fall and spring
Red drum	Summer, fall, and winter
Black drum	Fall and winter
Whiting	Summer, fall, winter, and spring
Sand seatrout	Fall, winter, and spring
Pinfish	Summer, fall, winter, and spring
Atlantic spadefish	Summer
Gray snapper	Summer

[a]Adapted from U.S. Army Corps of Engineers (1974b).

Table 2-51. Areal extent (acres) of emergent and submerged aquatic vegetation in the Tampa Bay system[a]

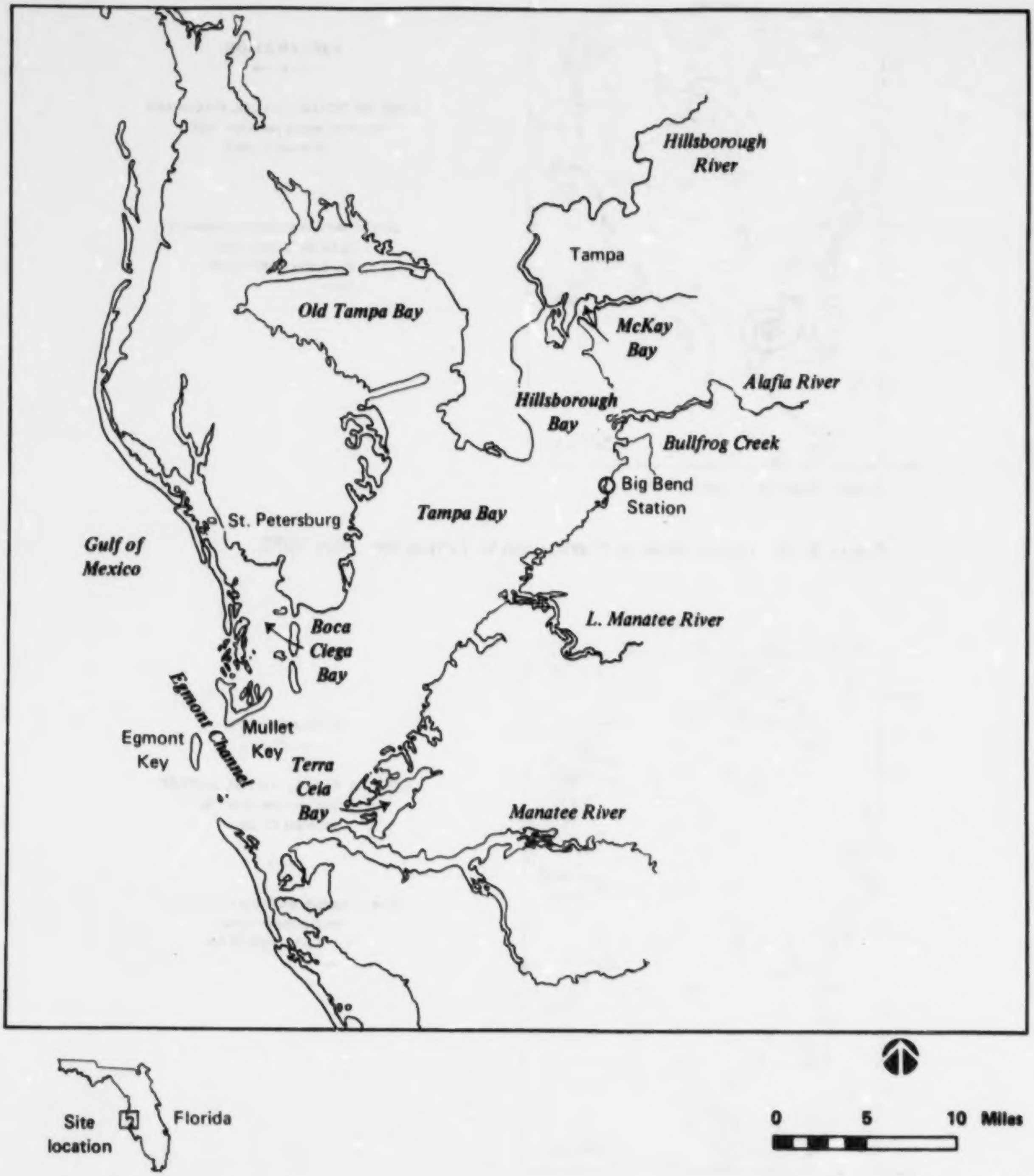
Subarea	Emergent vegetation Mangrove	 Tidal marsh	Submerged vegetation
Old Tampa Bay	5,024	533	6,809
Hillsborough Bay	1,077	203	383
Tampa Bay	8,949	843	7,890
Boca Ciega Bay	2,464	149	5,800

[a]Adapted from McNulty, Lindall, and Sykes (1972).

Table 2-52. Areal extent (acres) of filled and drained areas in the Tampa Bay system[a]

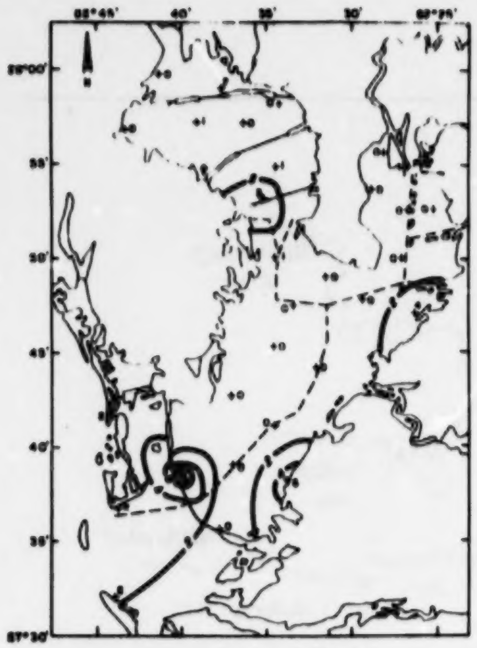
Subarea	Filled areas Causeways	 Housing, industry, and other	Drained tidal marsh
Old Tampa Bay	660	1,040	3,302
Hillsborough Bay	40	2,517	1,442
Tampa Bay	760	2,280	3,780
Boca Ciega Bay	77	2,997	1,058

[a]Adapted from McNulty, Lindall, and Sykes (1972).


Hillsborough River
Tampa
McKay Bay
Alafia River
Old Tampa Bay
Hillsborough Bay
Bullfrog Creek
Big Bend Station
St. Petersburg
Tampa Bay
Gulf of Mexico
L. Manatee River
Boca Ciega Bay
Egmont Channel
Egmont Key
Mullet Key
Terra Ceia Bay
Manatee River
Site location
Florida
0
5
10 Miles

Source: Tampa Electric Company (1975).

Figure 2-9. The Tampa Bay system and Big Bend Station.



82°45'
40'
35'
30'
82°25'
28°00'
55'
50'
45'
40'
35'
27°30'

EXPLANATION

—6—

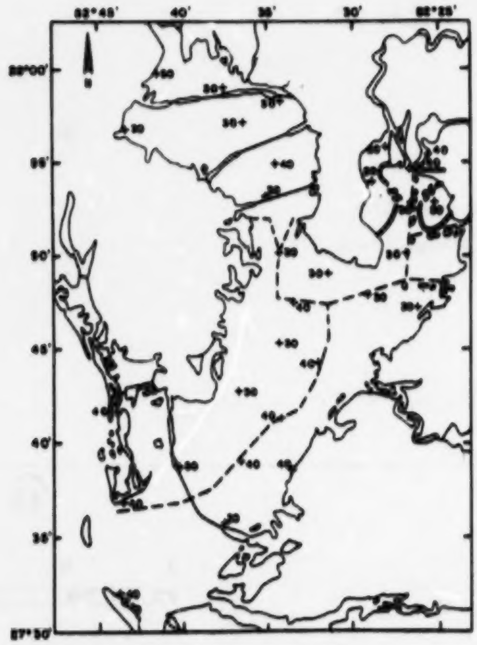
LINE OF EQUAL TOTAL CADMIUM
In micrograms per liter (μg/ℓ)
Interval 2 μg/ℓ

+6

Site of sample collection showing
total cadmium value
0 4 KILOMETERS

Source: Goetz and Goodwin (1980).

Figure 2-10. Total cadmium distribution in Tampa Bay, May 1973.



82°45'
40'
35'
30'
82°25'
28°00'
55'
50'
45'
40'
35'
27°30'

EXPLANATION

—25—

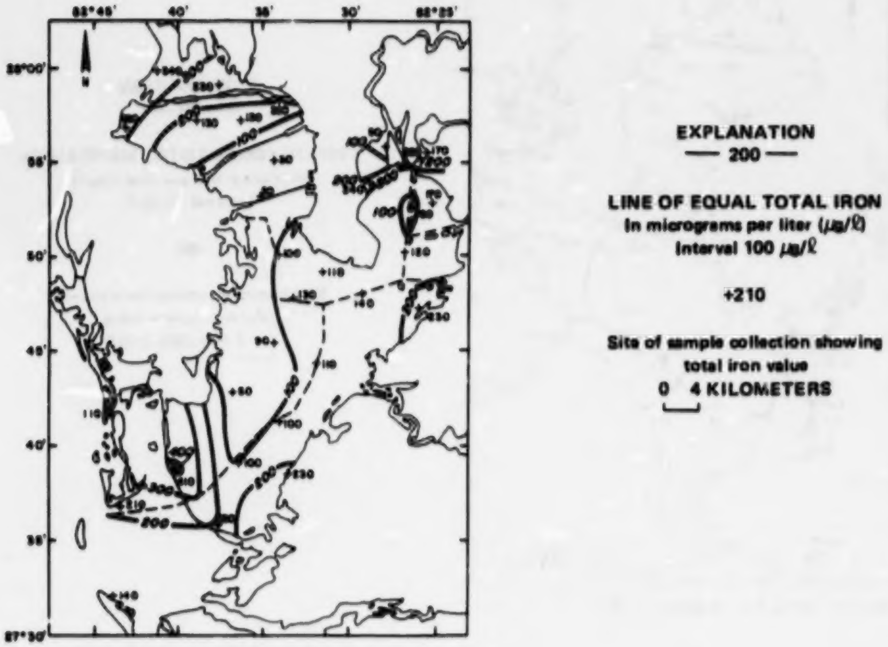
LINE OF EQUAL TOTAL COPPER
In micrograms per liter (μg/ℓ)
Interval 25 μg/ℓ

+40

Site of sample collection showing
total copper value
0 4 KILOMETERS

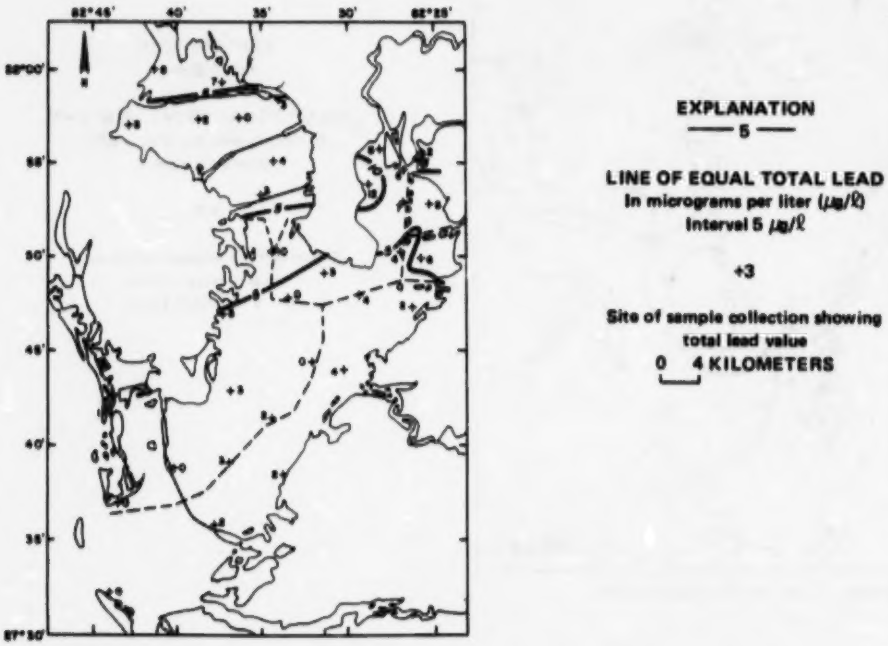
Source: Goetz and Goodwin (1980).

Figure 2-11. Total copper distribution in Tampa Bay, May 1973.


82°45'
40'
35'
30'
82°25'
28°00'
55'
50'
45'
40'
35'
27°30'
N
EXPLANATION
— 200 —
LINE OF EQUAL TOTAL IRON
In micrograms per liter (µg/ℓ)
Interval 100 µg/ℓ
+210
Site of sample collection showing
total iron value
0 4 KILOMETERS

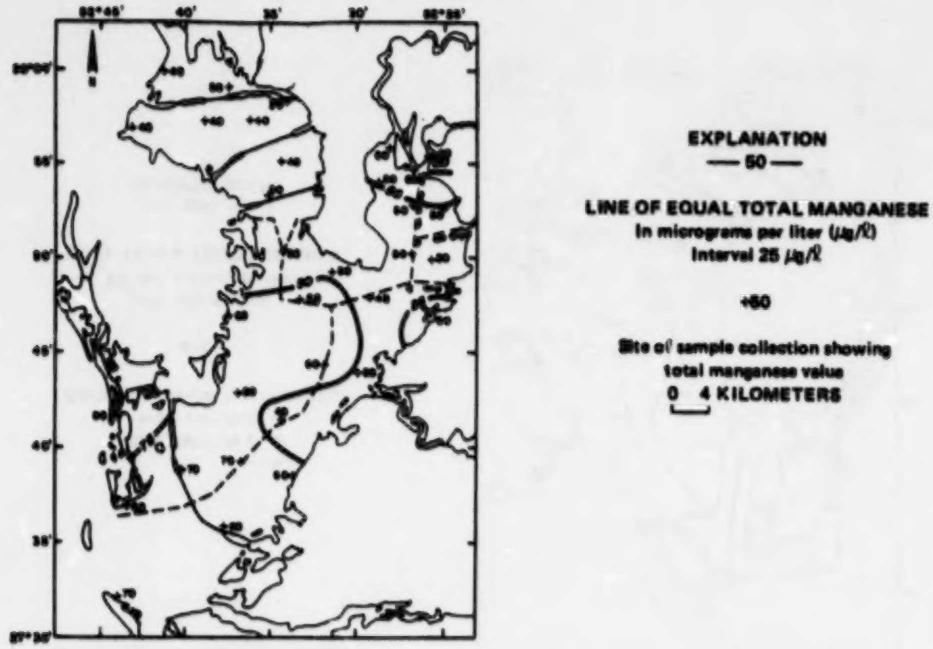
Source: Goetz and Goodwin (1980).

Figure 2-12. Total iron distribution in Tampa Bay, May 1973.


82°45'
40'
35'
30'
82°25'
28°00'
55'
50'
45'
40'
35'
27°30'
N
EXPLANATION
— 5 —
LINE OF EQUAL TOTAL LEAD
In micrograms per liter (µg/ℓ)
Interval 5 µg/ℓ
+3
Site of sample collection showing
total lead value
0 4 KILOMETERS

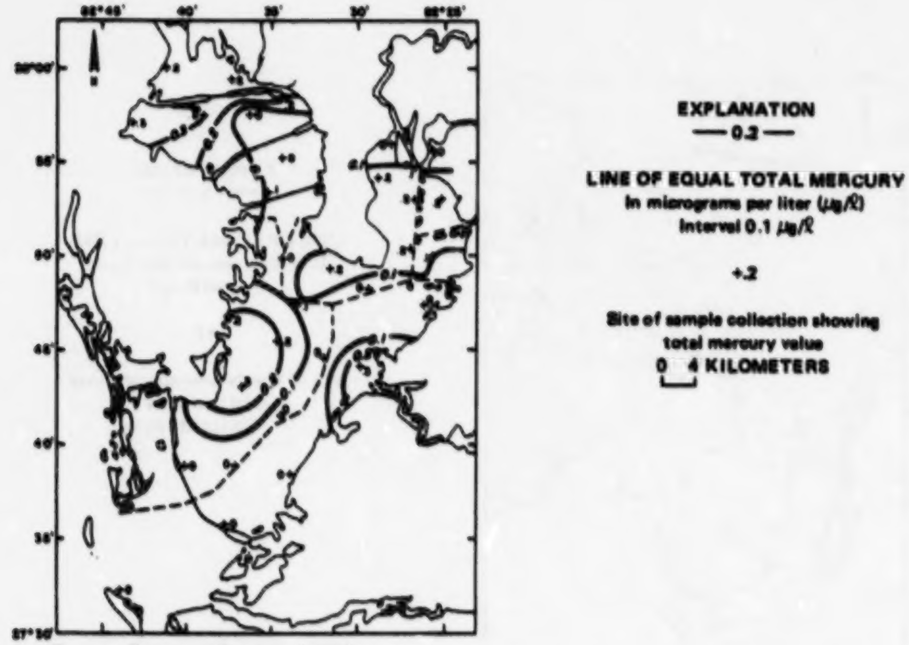
Source: Goetz and Goodwin (1980).

Figure 2-13. Total lead distribution in Tampa Bay, October 1975.


82°45'
40'
35'
30'
82°25'
28°00'
55'
50'
45'
40'
35'
27°30'
N
EXPLANATION
— 50 —
LINE OF EQUAL TOTAL MANGANESE
In micrograms per liter (µg/ℓ)
Interval 25 µg/ℓ
+50
Site of sample collection showing
total manganese value
0 4 KILOMETERS

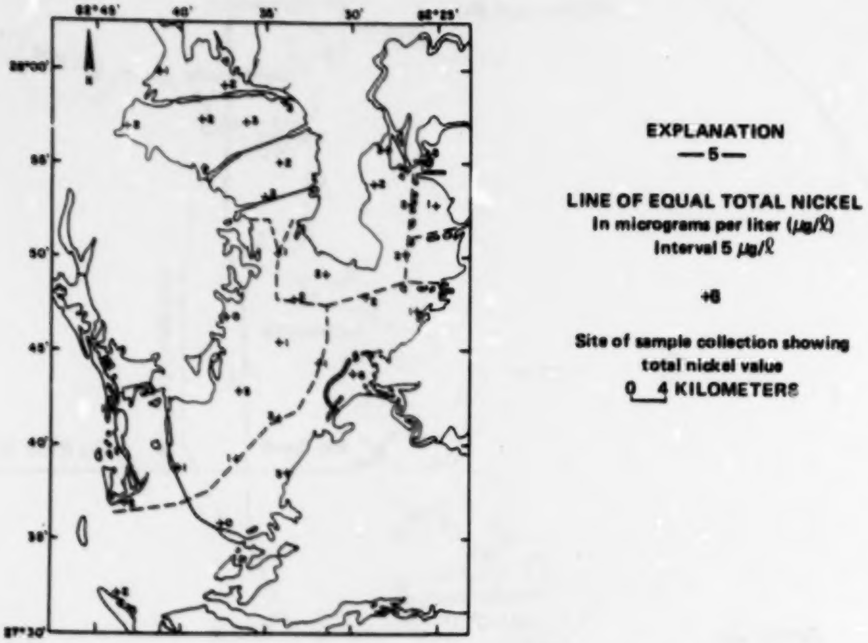
Source: Goetz and Goodwin (1980).

Figure 2-14. Total manganese distribution in Tampa Bay, October 1975.


82°45'
40'
35'
30'
82°25'
28°00'
55'
50'
45'
40'
35'
27°30'
N
EXPLANATION
— 0.2 —
LINE OF EQUAL TOTAL MERCURY
In micrograms per liter (µg/ℓ)
Interval 0.1 µg/ℓ
+.2
Site of sample collection showing
total mercury value
0 4 KILOMETERS

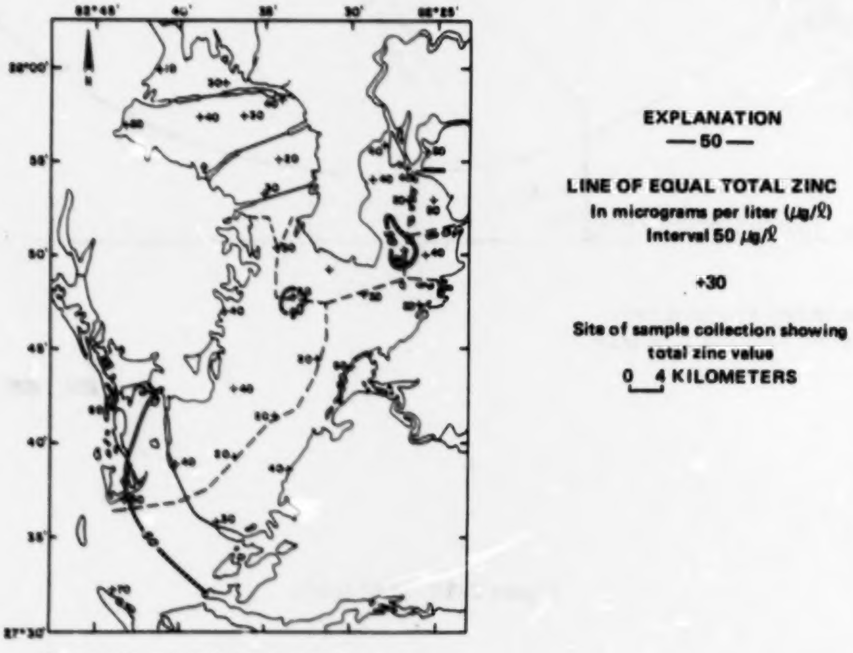
Source: Goetz and Goodwin (1980).

Figure 2-15. Total mercury distribution in Tampa Bay, October 1975.


82°45'
40'
35'
30'
82°25'
28°00'
55'
50'
45'
40'
35'
27°30'
N
EXPLANATION
—5—
LINE OF EQUAL TOTAL NICKEL
In micrograms per liter (µg/ℓ)
Interval 5 µg/ℓ
+6
Site of sample collection showing
total nickel value
0 4 KILOMETERS

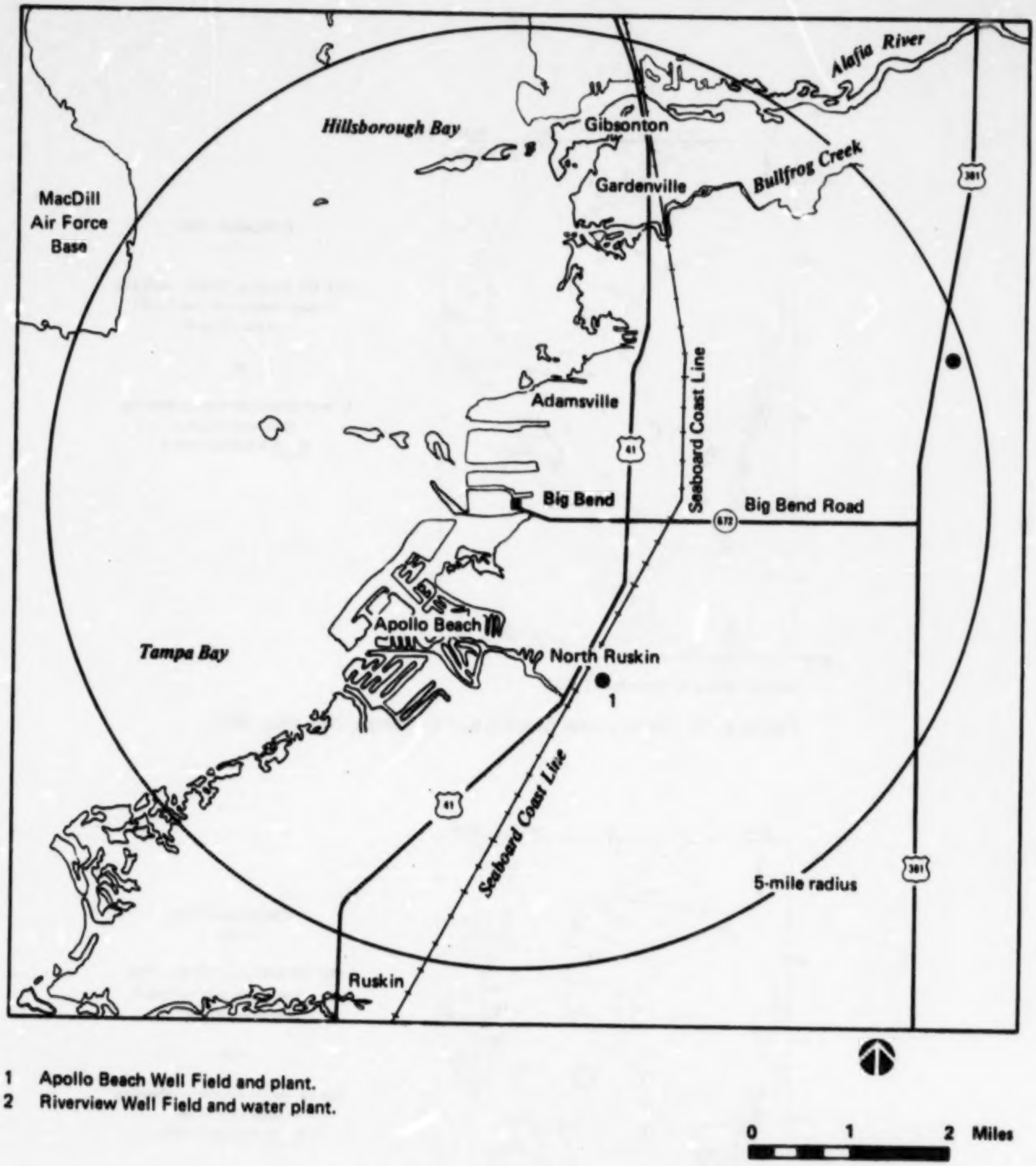
Source: Goetz and Goodwin (1980).

Figure 2-16. Total nickel distribution in Tampa Bay, May 1973.


82°45'
40'
35'
30'
82°25'
28°00'
55'
50'
45'
40'
35'
27°30'
N
EXPLANATION
—50—
LINE OF EQUAL TOTAL ZINC
In micrograms per liter (µg/ℓ)
Interval 50 µg/ℓ
+30
Site of sample collection showing
total zinc value
0 4 KILOMETERS

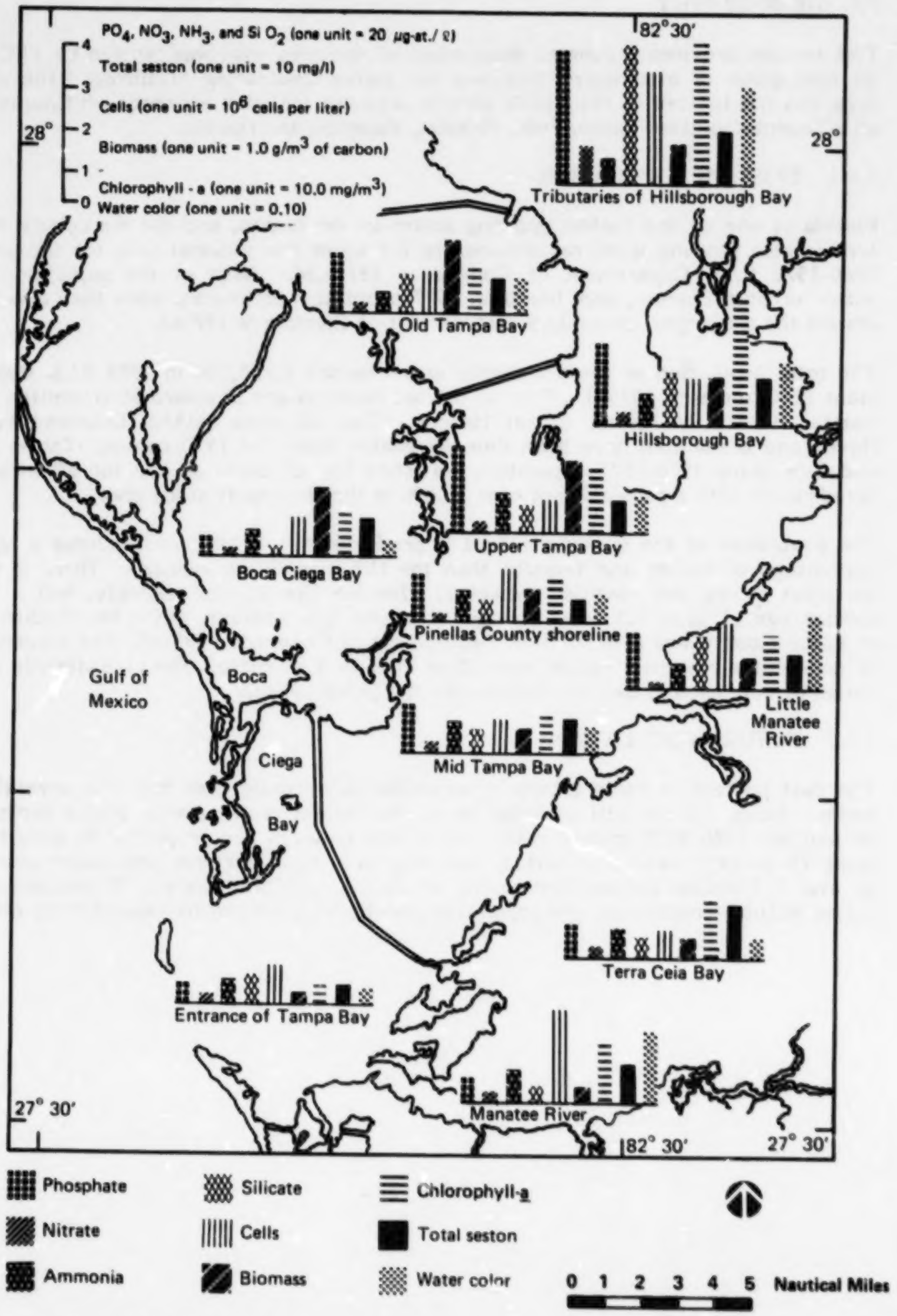
Source : Goetz and Goodwin (1980).

Figure 2-17. Total zinc distribution in Tampa Bay, October 1975.


Alafia River
Hillsborough Bay
Gibsonton
Gardenville
Bullfrog Creek
301
MacDill
Air Force
Base
Seaboard Coast Line
Adamsville
41
Big Bend
Big Bend Road
672
Apollo Beach
Tampa Bay
North Ruskin
1
41
Seaboard Coast Line
301
5-mile radius
Ruskin
0
1
2
Miles

1 Apollo Beach Well Field and plant.
2 Riverview Well Field and water plant.

Figure 2-18. Well fields.


PO4, NO3, NH3, and Si O2 (one unit = 20 µg-at./ℓ)
Total seston (one unit = 10 mg/l)
Cells (one unit = 10^6 cells per liter)
Biomass (one unit = 1.0 g/m³ of carbon)
Chlorophyll - a (one unit = 10.0 mg/m³)
Water color (one unit = 0.10)
4
3
2
1
0
28°
82°30′
28°
Tributaries of Hillsborough Bay
Old Tampa Bay
Hillsborough Bay
Upper Tampa Bay
Boca Ciega Bay
Pinellas County shoreline
Little Manatee River
Gulf of Mexico
Boca
Ciega
Bay
Mid Tampa Bay
Terra Ceia Bay
Entrance of Tampa Bay
Manatee River
27° 30′
82° 30′
27° 30′
Phosphate
Nitrate
Ammonia
Silicate
Cells
Biomass
Chlorophyll-a
Total seston
Water color
0 1 2 3 4 5 Nautical Miles

Source: Turner and Hopkins (1974).

Figure 2-19. Chemical, physical, and phytoplankton data, averaged for different regions of the Tampa Bay system in 1969-1970.

2.4 DEMOGRAPHY

This section provides a general description of the area that was studied by TECO in its evaluation of alternative locations for future generating facilities. The study area was not limited to the TECO service area but included Hillsborough County and all adjacent counties—Pasco, Polk, Pinellas, Manatee, and Hardee.

2.4.1 EXISTING POPULATION

Florida is one of the fastest growing states in the nation, and the six-county study area is also growing quite rapidly—nearly 2.5 times the national rate for the period 1960-1970 (U.S. Department of Commerce 1971a,b). Most of the population lies within urbanized areas, and, based on 1977 population estimates, more than one-third inhabit the six largest cities (U.S. Department of Commerce 1979a).

The total population of the six-county area reached 1,798,924 in 1977 (U.S. Department of Commerce 1979a). Five of the six counties are Standard Metropolitan Statistical Areas (SMSA)—all except Hardee. Two of these SMSAs, Lakeland-Winter Haven and Bradenton, have been thus designated since the 1970 census. Tables 2-53 and 2-54 show 1970-1977 population statistics for all counties and for all incorporated places with a population of over 10,000 in the six-county study area.

The population of the six-county area is predominantly elderly and includes a higher percentage of whites and females than the U.S. population average. There is wide variation among the counties, however. Hardee County, for example, had a 1970 median age of 26.6, 1.5 years younger than the U.S. average, while the median age in Pasco County was over 53 (U.S. Department of Commerce 1971b). The percentage of non-whites presently varies from 15 in Polk to 3 in Pasco. The male-female ratio varies by only about 5 percent (University of Florida 1979a).

2.4.2 FUTURE POPULATION

The past pattern of rapid growth is expected to continue over the next several decades. Pasco County will continue to be the fastest growing area with a projected 96 percent 1980-2020 growth rate. All of the counties are projected to grow by at least 72 percent over this period, resulting in a total regional population increase of over 1.5 million persons (University of Florida 1979b). Table 2-55 presents estimates of future population and population growth rates for the six-county study area.

Table 2-53. Total population and population density for counties in study area[a]

County	1970 population	1977 population	Percentage increase 1970–1977	1977 population density, persons per square mile
Hardee	14,889	16,739	12.4	26.6
Hillsborough	490,265	583,383	19.0	562.0
Manatee	97,115	125,300	29.0	169.6
Pasco	75,955	142,033	87.0	191.4
Pinellas	522,329	654,294	25.3	2,469.0
Polk	228,515	277,175	21.3	149.2
Total	1,429,068	1,798,924	25.9	341.3

[a] From U.S. Department of Commerce (1971a, 1979b).

Table 2-54. Incorporated places over 10,000 population[a]

Place	1977 population	1970 population	Percentage change
Plant City	15,726	16,474	−4.5
Tampa	264,884	277,714	−4.6
Temple Terrace	10,568	7,347	+43.8
Bradenton	26,103	21,040	+24.1
Clearwater	75,492	53,543	+41.0
Dunedin	26,438	17,639	+49.9
Gulfport	11,327	9,976	+13.5
Largo	49,301	26,957	+82.9
Pinellas Park	28,069	22,287	+25.9
St. Petersburg Beach	10,053	8,024	+25.3
St. Petersburg	237,134	216,159	+9.7
Tarpon Springs	11,601	7,118	+63.0
Bartow	13,936	12,891	+8.1
Lakeland	48,727	44,150	+10.4
Winter Haven	19,042	16,136	+18.0

[a] From U.S. Department of Commerce (1979b).

Table 2-55. Future populations of counties within the study area[a]

County	1980 population	1990 population	2000 population	2020 population	Percentage increase 1980-2020
Hardee	18,500	22,100	25,700	31,800	72
Hillsborough	644,000	783,500	910,900	1,126,800	75
Manatee	144,000	181,100	210,500	260,400	81
Pasco	166,800	226,900	263,900	326,400	96
Pinellas	749,700	934,900	1,087,000	1,344,600	79
Polk	296,900	360,000	418,600	517,800	74
Total	2,019,900	2,508,500	2,916,600	3,607,800	77

[a] From University of Florida (1979b).

2.5 ECONOMICS

2.5.1 PRESENT

Retail trade accounted for nearly 19 percent of the region's total generated payroll in 1977. Other major business sectors contributing to the region's economy were manufacturing (21 percent), services (21 percent), and finance (9 percent). The agricultural sector contributed less than 1 percent to the region's total payroll. Of the six counties, Polk had the largest manufacturing sector, Pinellas had the largest services and finance sectors, and Hardee had the largest retail sector. Hardee County also had the largest agricultural sector (9 percent). This percentage was much higher than those of the other counties, which ranged from 0.38 percent (Pinellas) to 1.7 percent (Pasco). Pinellas County had the largest number of business establishments and a more diversified business community (U.S. Department of Commerce 1979b).

Unemployment figures for 1978 in the six counties were as follows: 5.5 percent in Hillsborough, 6.3 percent in Pinellas, 8.1 percent in Pasco, 10.4 percent in Polk, 6.8 percent in Hardee, and 5.0 percent in Manatee (Florida Department of Commerce 1979). All of the counties except Hardee experienced a drop in unemployment between 1977 and 1978; in Hardee County the unemployment rate increased by 0.1 percent. Despite this, only the Hillsborough and Manatee figures for 1978 were below the national average of 6.0 percent for that year (Norman Bowers, U.S. Department of Labor, Bureau of Labor Statistics, personal communication, January 9, 1980).

2.5.2 FUTURE

Total personal income for the region rose sharply over the period 1970-1977. The breakdown by county shows increases of 113 percent in Hillsborough, 111 percent in Hardee, 241 percent in Pasco, 122 percent in Polk, 145 percent in Manatee, and 127 percent in Pinellas (University of Florida, undated). During this same period, the average per capita income in the six counties rose by approximately 80 percent (University of Florida, undated; U.S. Department of Commerce 1979b).

Projections of future economic activity within the study area indicate that the upward trend will continue. Total personal income in the Tampa Bureau of Economic Analysis forecast area, which includes the study area, is projected to increase by 59 percent between 1980 and 1990 and by another 219 percent between 1990 and 2020. Projections by the Office of Business Economics and Research Services indicate that during this same period per capita income will rise by about 285 percent (to $12,000 per person). These projections, however, do not indicate any dramatic changes in the breakdown of income in the various economic sectors. Between 1980 and 2020, the shares of total income will increase for the services sector, the finance, insurance, and real estate sector, and the government employment sector, while the shares of other sectors will decrease slightly (U.S. Water Resources Council 1972). Such trends are typical for a maturing metropolitan area.

2.6 LAND USE

2.6.1 EXISTING LAND USE

2.6.1.1 Agricultural Land Use

The counties in the study area have been developing rapidly over the past two decades and, although each county still possesses rural sections beyond the fringes of urban development, the total farmland area is shrinking. Cropland is not the primary land use in any of the counties in the study area. It occupied only 17 percent of the region's land area in 1974 and, of the six counties, Hardee County had the highest percentage (20.4 percent) and Pinellas County had the lowest (5 percent). Total cropland in the remaining counties was 16.7 percent in Hillsborough, 15.8 percent in Pasco, 19.8 percent in Polk, and 13.9 percent in Manatee. Table 2-56 provides figures on total agricultural acreage and on the different categories of agricultural acreage for each county (U.S. Department of Commerce 1977).

2.6.1.2 Residential Land Use

Residential land use in the six-county region ranges from extremely low-density to extremely high-density development. This development is concentrated in cities and towns in adjacent suburban areas, and along major transportation corridors. The land between these urbanized areas is generally open space, swamp, forest, or land devoted to agriculture or phosphate mining.

In Hillsborough County, for example, residential development is heavily concentrated around Tampa. This development has spread north and south along I-75, east along I-4, and west along State Route 580. Development north of the city has been influenced by the University of South Florida, various industrial and commercial facilities, and the region's scenic lakes. Residential centers in this area are Temple Terrace, Lutz, and Nowatney. To the east, the major residential nodes are Brandon, Plant City, and various smaller communities hugging I-4 and State Highway 574. Smaller residential areas, including Ruskin and Gibsonton, dot the county's Tampa Bay coastline. Increasingly, residential development is spreading southwest of Tampa as recreational and bedroom communities are built along the Old Tampa Bay shoreline. Development in the southeastern portion of the county is sparse; it is associated mainly with transportation corridors or small residential nodes such as Ft. Lonesome or Picnic (Texas Instruments, Inc. 1978b).

In Pinellas County, south of State Route 60, the county is largely urbanized and shows heavy residential development with little open space. The residential communities are side by side and bear such names as Clearwater, Pinellas Park, Kenneth City, and St. Petersburg. North of State Route 60, the county is largely agricultural land or open space; the only major residential developments are centered around Tarpon Springs (Pinellas County Planning Department 1976) and Dunedin.

North of I-4 in Polk County, the major residential zones are Gibsonia and Providence along U.S. 98. In the central portion of the county, between I-4 and State Route 60, the major residential zones are Lakeland and Winter Haven along U.S. 92 and Bartow and Lake Wales along State Route 60. Haines City and Mulberry are also major residential nodes in this area of the county. The major residential center south of State Route 60 is Ft. Meade. The area's remaining residents are scattered on farms or along transportation corridors (Texas Instruments, Inc. 1978b).

Residential development in Pasco County is centered along U.S. 19 (Port Richey-New Port Richey urban area), U.S. 301 (Zephyrhills, Dade City, and Lachoochee), and U.S. 41 (Land O' Lakes). East of U.S. 19, beyond the urbanized area, Moon Lake Estates is also a fairly large residential development. The remaining portions of the county are largely marsh, agricultural land, or mining regions, with scattered residential clusters (Pasco County Planning Department 1978, Pasco County Planning Department, undated).

Hardee County is largely agricultural, and residential development is limited. Less than 1 percent of the county's land area is in residential use. The major residential areas parallel the Peace River along U.S. 17. The county's three incorporated areas are Bowling Green, Wachula, and Zolfo Springs. The remaining area consists of scattered residential communities catering to agricultural activities (Texas Instruments, Inc. 1978b).

In Manatee County, development is generally centered along the coast in the area of Bradenton. North of Palmetto, residential land use follows U.S. 19 and U.S. 41. The area west of Bradenton is another major center of residential growth, spurred by the attractiveness of gulf-side living. Development around Bradenton also extends eastward along the Manatee River. The area south and southwest of Bradenton is characterized by a mixture of residential and commercial land use. The eastern portion of the county is rather underdeveloped, and the small agriculturally oriented communities of Myakka City, Manhattan, and Parish serve mainly as convenience centers for the area's scattered residential population (Texas Instruments, Inc. 1978b).

2.6.1.3 Commercial Land Use

This region's commercial areas are located primarily in central business districts (CBDs) or highway strip developments. In Hillsborough County, highway strip zones serve the urbanized areas along I-75, I-4, and State Route 580. In addition, several large commercial complexes are found along I-75 near the University of South Florida and along State Route 580 near the Tampa International Airport. Interstate 4 is also a heavily commercialized corridor, mainly because of Disney World development in the Orlando area. Commercial pockets along the coast are associated with residential areas such as Ruskin. Commercial land use is light in the southeast portion of the county, where the emphasis is on service to scattered residential areas (Texas Instruments, Inc. 1978b).

In Polk County, commercial land use is concentrated in the CBDs and along access roads to the major population centers, Lakeland and Winter Haven, and in a few surrounding towns and communities. The commercial emphasis is retail business in the CBDs, but there are also a few highway strip commercial zones (Texas Instruments, Inc. 1978b).

Commercial areas are distributed in Pinellas County much the same as in the other portions of the study area. The St. Petersburg CBD and major arterials leading into the city are primary areas of commercial land use. Other large commercial areas are located in the surrounding towns of Clearwater, Pinellas Park, and St. Petersburg Beach (Pinellas County Planning Department 1976). Major commercial areas in Pasco County are situated in or near Dade City and Zephyrhills. Others are dispersed lightly along highways and main streets (Pasco County Planning Department 1978; Pasco County Planning Department, undated).

In Hardee County, commercial land use is generally restricted to the three incorporated areas of Bowling Green, Wachula, and Zolfo Springs. Commercial land use is most dense in Wachula, as commercial convenience centers have become more evident in response to residential growth. Throughout the remaining portions of the county, commercial activity is extremely light and is only associated with small, rural communities (Texas Instruments, Inc. 1978b).

In Manatee County, the primary commercial development is associated with the urban area around Bradenton along the coast. North of Palmetto, commercial land use is found along U.S. 41 and U.S. 301, and the proposed I-75 alignment has begun to lure additional development into the area. South and southwest of Bradenton, commercial growth has been influenced by U.S. 41, U.S. 301, and the Sarasota-Bradenton Airport, as well as the region's residential communities. In the eastern portions of the county, rural community centers may support light commercial activity (Texas Instruments, Inc. 1978b).

2.6.1.4 Industrial Land Use

Industrial land constitutes a minor portion of the total land within the study area. In Hillsborough County, the primary industrial area is southeast of Tampa around McKay Bay. This area is dominated by parts facilities and heavy industry. Surrounding it is an area of lighter industry which is spreading south along the shore of Tampa Bay and east along State Route 60. Other industrial areas are developing along I-4 East, at Tampa International Airport, and at a new commercial-industrial complex adjacent to the University of South Florida (Texas Instruments, Inc. 1978b; Hillsborough County Board of County Commissioners 1978).

The major area of industrial land use in Polk County is its southwestern corner. Phosphate mining and associated industrial activity dominate this area. Some agricultural and phosphate-related industry can also be found in the highly developed center of the county (Texas Instruments, Inc. 1978b).

Industrial areas in Pinellas County are located primarily near the three major airports, St. Petersburg-Clearwater, Clearwater Executive, and Albert Whitted. In the southern half of the county, pockets of industrialized land follow the Seaboard Railroad northwest. The only industrialized areas in the north are located north of Tarpon Springs near the Pinellas County border (Pinellas County Planning Department 1976).

Pasco County's industrial land use, as is the case with residential and commercial land use, is concentrated along the three major transportation arteries, particularly in the Dade City-Zephyrhills area along U.S. 301. The land is devoted primarily to agricultural processing plants and phosphate mines (Pasco County Planning Department 1978; Pasco County Planning Department, undated).

Industry in Hardee County is limited to the three urban areas, the principal area being Wachula (Pinellas County Planning Department 1976).

In Manatee County, the largest concentrations of industrial land are found near Port Manatee, the Sarasota-Bradenton Airport, and within the industrial parks located along U.S. 301. Small areas of agriculture-related industrial activity may also be found in the eastern portion of the county because of this region's emphasis on farming (Pinellas County Planning Department 1976).

2.6.2 FUTURE LAND USE

2.6.2.1 Future Agricultural Land Use

Within the six-county region, cropland used for grazing/pasture and irrigated farmland increased 13.9 percent and 6.1 percent, respectively, between 1969 and 1974. These increases, however, were offset by the 9 percent decrease in harvested croplands and the 3.5 percent decrease in idle croplands or croplands used for improvement crops or summer fallow. Consequently, the total cropland in the region decreased 2.1 percent during this period. Despite this overall drop, Manatee and Polk Counties experienced an increase in total croplands between the two years. The changes in woodland, irrigated land, and grazing land varied from county to county. Table 2-57 shows the percentage changes in each county from 1969 to 1974.

The decrease in overall cropland and woodland will probably continue in the future as residential, commercial, and industrial land use grows in each county. Land reclaimed from phosphate mining may provide additional usable acreage. This land, however, would most likely be used for grazing and pasture and not for cropland (Texas Instruments, Inc. 1978b; Pinellas County Planning Department 1979; Pasco County Planning Department, undated).

2.6.2.2 Future Residential Land Use

Trends indicate that population increases will push development beyond existing population centers, with most new growth taking place on land adjacent to current urban areas. In Hillsborough County, for example, the existing cities of Tampa and Temple Terrace will undergo high-density residential growth, but growth is also expected to continue in the fringe areas of Tampa. This growth will extend north into the Citrus Park-Fern Lake area and east into the Brandon area. Residential development may continue along the I-4 transportation corridor, concentrating in Plant City and other existing communities. Moderate growth is predicted for the U.S. 301-U.S. 41 corridor south of Gibsonton. Residential development is also planned in the rural southwest area, but it is expected to be less than one dwelling per gross acre (Texas Instruments, Inc. 1978b).

Major residential growth is also forecast for Polk County. The Cypresswood and other large developments are planned for Davenport and the area near Dundee. Lakeland and Winter Haven, the county's major urban centers, will also grow. This growth will be accommodated either by an increase in population density or by expansion to outlying areas such as Bartow and Haines City. Auburndale, located north of Winter Haven, will also expand its residential centers, as may southeast Winter Haven. The region's numerous lakes are expected to produce increased tourism, stimulating growth in Lake Wales as well as Haines City. Growth is also anticipated along the county's transportation corridors as the population increases. In the county's southern portion, the heavy emphasis on phosphate mining is expected to limit residential development and population growth in the near future. By the year 2000, however, mined lands may undergo reclamation, which in turn could spur residential and commercial development along transportation routes or near existing residential clusters (Texas Instruments, Inc. 1978b).

Pinellas County is already the most developed of the six counties in the study area. It is anticipated that further residential development will be accommodated by higher density development in the southern half of the county and by movement into presently undeveloped land in the northeast. Many of the existing single-family areas, however, may remain as low-density residential areas in the future. The open area around Lake Seminole is planned for recreational open space and a large residential area. The open area along McKay Creek is projected to remain open space or residential, while large residential areas are anticipated in southern Seminole and in northern Pinellas Park. West of the St. Petersburg-Clearwater Airport, large tracts of residential land are projected. The most dramatic increase in residential land, however, may occur north of State Route 60. Much of the remaining open space in Tarpon Springs is planned for residential use in the future. Its population is expected to spread east and south, while Dunedin expands northward, until the entire region consists of vast residential areas together with supporting commercial facilities. Lastly, it is anticipated that the marshland east of Lake Tarpon will become a region of open and recreational land intermixed with large tracts devoted to residential use (Pinellas County Planning Department 1979).

Pasco County's increasing population will expand the existing residential corridors paralleling U.S. 19, U.S. 41, and U.S. 301. The county has acres of open space between these corridors to accommodate this growth. Zephyrhills and Dade City are planned to expand in all directions. Along U.S. 41 the corridor may widen, particularly around Land O' Lakes. The development along the gulf coast will intensify and spread further inland (Pasco County Planning Department, undated).

In Hardee County, residential growth is anticipated along U.S. 17 in the existing communities of Bowling Green, Zolfo Springs, and especially Wachula. Zolfo Springs will expand eastward, while Wachula's residential development should be southward to Zolfo Springs along the Peace River and also eastward. Residential development along the Peace River waterfront is expected to increase in both of these cities. The agricultural area west of U.S. 17, bounded by State Routes 62 and 64 and by the Seaboard Coast Line, is expected to become residential in the future. Throughout the county, residential centers will continue to expand and to encroach on surrounding agricultural areas. Such expansion, however, will not totally eliminate the croplands/pastures and orchards/groves currently situated between urban areas, and agricultural land may continue to occupy almost half of the land area of the county (Texas Instruments, Inc. 1978b).

In Manatee County, extensive development is anticipated along the coast, leading to complete urbanization of the coastal area by the year 2035. Terra Ceia, Snead, and other off-shore islands will attract increased residential development in the future, although Bradenton and Palmetto will remain the dominant urban centers. Residential development in Palmetto will intensify, but the city's current residential land-use pattern is not expected to change in the future. Bradenton is also expected to retain its urban form as residential land use intensifies and expands. Residential growth will continue west and southwest of the city, particularly on Anna Maria and Long Boat Keys and in the area surrounding Palma Sola Bay. Southeast of Bradenton, residential growth will continue in response to the influence of U.S. 41 and U.S. 301. Completion of the proposed I-75 alignment may increase residential development in this region. East of I-75, the landscape is expected to retain its rural character. Development in Myakka City, Manhattan, and Parish should intensify, but this will not alter their size considerably (Texas Instruments, Inc. 1978b).

2.6.2.3 Future Commercial Land Use

Commercial areas in the six-county region are projected to expand to support the region's residential growth. In Hillsborough County, commercial facilities will be developed in new residential areas and along transportation routes. This development will be centered in the Brandon, southwest Tampa, and Citrus Park-Lake Fern areas, and along I-4, State Route 580, U.S. 41 and U.S. 301. In the southeast, commercial activity may continue to support the sparse population, growing as the population grows (Texas Instruments, Inc. 1978b).

In Polk County, Auburndale is expected to expand its commercial activities. Increased tourism attributable to the county's numerous lakes and forested areas may also bring about expansion of the trade and service centers associated with cities such as Lake Wales and Haines City. Transportation and railroad corridors will stimulate commercial and residential growth west of these cities toward Winter Haven. Since Winter Haven and Lakeland are already developed, increased use of existing facilities may be more common than further expansion. In the southern portion of the county, commercial land use will increase along transportation routes once the area's phosphate mining activities are reduced sometime after 1985 (Texas Instruments, Inc. 1978b).

In Pinellas County, commercial land use is expected to increase along major transportation corridors such as U.S. 19 and 60 and State Routes 699, 687, and 595. Land-use plans further indicate that the St. Petersburg CBD will be more intensely developed and even become more consolidated. North of U.S. 60, commercial development will increase along State Route 595. A large section of land at the junction of State Route 580 and U.S. 19 will become commercial and the commercial zones in Tarpon Springs may expand to support the city's increased residential development (Pinellas County Planning Department 1979).

Pasco County's commercial land use will primarily follow expanding residential development. Major concentrations of commercial land use will also be found in the CBDs of the existing communities of Dade City, Zephyrhills, Port Richey, and New Port Richey. Two additional commercial areas are planned west of Dade City in St. Leo and San Antonio. Large commercial strips are projected along U.S. 41 through Land O' Lakes, along the eastern portions of State Route 52, and all along U.S. 19 (Pasco County Planning Department, undated).

In Hardee County, commercial development is expected to increase in conjunction with residential growth. Thus, commercial land use will expand along U.S. 17 and State Routes 64 and 62 and within the expanding communities of Zolfo Springs, Bowling Green, and Wachula. Possible expansion of the county's east-west corridor may turn Wachula into a regional commercial center for the rural counties of Hardee, DeSoto, and Highlands. The remaining commercial land use may be in support of the county's sparse rural population (Texas Instruments, Inc. 1978b).

In Manatee County, commercial activity is expected to expand in Palmetto and Bradenton to accommodate these cities' growing populations. This phenomenon, however, will be confined mainly to the CBD of each city. Highway-oriented commercial facilities may expand along U.S. 41 and U.S. 301, and also along I-75 after its completion. East of I-75, commercial activity will remain light, serving mainly the existing communities of Myakka City, Manhattan, and Parish (Texas Instruments, Inc. 1978b).

2.6.2.4 Future Industrial Land Use

The Hillsborough County Planning Commission expects that the county's industrial areas will expand and that Hillsborough will continue to be the most heavily industrialized county in the study area. Industrial parks will be the preferred form of industrial land use, probable sites for these parks being Tampa International Airport, the area between Tampa and Brandon, and the Plant City area. Heavy industrial activity is anticipated along the northeastern shore of Tampa Bay, around McKay Bay, northwest of Gibsonton, in western Temple Terrace, and north of the Tampa International Airport (Texas Instruments, Inc. 1978b; Hillsborough County Board of County Commissioners 1978).

The Pinellas County Planning Department anticipates the use of large tracts of county land for manufacturing. The areas proposed are south and southwest of the St. Petersburg-Clearwater International Airport, north of the Clearwater Executive Airport, and along the tracks of the Seaboard Coast Line Railroad from State Route 688 to just west of downtown St. Petersburg. An industrial/manufacturing area is also planned for northern Tarpon Springs (Pinellas County Planning Department 1979).

Industrial facilities are expected to occupy 1.95 percent of the Polk County land in 1985 as compared to 1.61 percent in 1975. This slight increase will derive mainly from industry associated with future mining activity. By the year 2000, however, industrial land use is expected to drop back to 1.62 percent, because of a decrease in phosphate reserves and mining operations. When this occurs, much of the mining areas will undergo reclamation, becoming agricultural land and pastureland or a mix of urban and industrial land (Texas Instruments, Inc. 1978b).

In Pasco County, most of the planned industrial areas are along U.S. 301 east of Dade City, Zephyrhills, and Lachoochee. A few small pockets of industrial land are planned along the Seaboard Coast Line Railroad through the central portion of the county (Pasco County Planning Department, undated). Isolated industrial areas will also be scattered along the U.S. 19 corridor.

The extensive, untapped phosphate reserves in Hardee County will be developed over the next 20 years, resulting in a major increase in industrial land use. The county's mines will remain active longer than those in Polk and Hillsborough Counties. Large tracts of agricultural land and rangeland will be converted to phosphate mining and its associated industrial activity. Most of these areas will be in the vicinity of Wachula and Bowling Green (Texas Instruments, Inc. 1978b).

Industrial land use in Manatee County will expand significantly over the next two decades, mainly because of increases in phosphate mining and related activities. Phosphate mining will become the primary land use in the northeastern and east-central portions of the county. Industrial activity in Port Manatee will expand as the mines are developed, since shipping out of the port will be less expensive than through Tampa. Industrial land use in other parts of the county will follow present patterns, but it will intensify and expand. The corridor along Route 301 will receive a major share of the remaining industrial growth. This corridor will extend from Sarasota County north to the Manatee River and will take in areas adjacent to the Sarasota-Bradenton airport and other major transportation facilities (Texas Instruments, Inc. 1978b).

Table 2-56. Agricultural acreage, 1974[a]

	Land use						
County	Total acreage	Total cropland[b]	Harvested cropland	Cropland used for grazing/pasture	Other cropland	Total woodland	Irrigated land
Hardee	402,560	81,875	45,264	33,525	3,085	42,341	39,705
Hillsborough	664,320	110,945	58,274	46,511	6,160	63,672	26,359
Manatee	472,960	65,857	34,264	27,612	3,981	95,225	29,952
Pasco	474,880	75,114	40,727	27,980	6,407	57,305	12,901
Pinellas	169,600	8,815	5,747	1,713	1,355	1,535	2,130
Polk	1,189,120	236,371	169,282	57,423	9,666	148,067	118,993

[a] From U.S. Department of Commerce (1977).

[b] Includes land in orchards.

Table 2-57. Change in agricultural acreage, 1969-1974[a]

	Land use					
County	Total cropland	Harvested cropland	Cropland used for grazing/pasture	Other cropland	Total woodland	Irrigated land
Hardee						
1969	87,391	52,659	32,094	2,638	67,743	29,319
1974	81,875	45,264	33,525	3,086	42,341	39,705
% change	-6.3	-14.0	+4.5	+17.1	-37.5	+35.4
Hillsborough						
1969	117,712	68,204	39,614	9,894	101,777	29,762
1974	110,945	58,274	46,511	6,160	63,672	26,359
% change	-5.7	-14.6	+17.4	-37.7	-37.4	-11.4
Manatee						
1969	57,040	30,717	20,927	5,396	50,378	25,083
1974	65,857	34,264	27,612	3,981	95,225	29,952
% change	+15.5	+11.5	+31.9	-26.2	+89.0	+19.4
Pasco						
1969	92,523	60,627	26,476	5,420	51,722	18,771
1974	75,114	40,727	27,980	6,407	57,305	12,901
% change	-18.8	-32.8	+5.7	+18.2	+10.8	-31.3
Pinellas						
1969	9,219	6,014	2,729	476	2,657	3,386
1974	8,815	5,747	1,713	1,355	1,535	2,130
% change	-4.4	-4.4	-37.2	+184.7	42.2	-37.1
Polk						
1969	227,292	170,118	49,223	7,951	223,771	110,448
1974	236,371	169,282	57,423	9,666	148,067	118,993
% change	+4.0	-0.5	+16.7	+21.6	-33.8	+7.7

[a] From U.S. Department of Commerce (1977).

2.7 TRANSPORTATION

The transportation network serving Hillsborough, Polk, Pasco, Pinellas, Manatee, and Hardee Counties consists of rail lines; the Port of Tampa; interstate, state, and county roads; and freight and passenger air service. Tampa is the primary transportation hub in the study area.

2.7.1 RAILROADS

Between Tampa and western Polk County lies one of Florida's densest concentrations of railroad track. Running west to east, these lines serve primarily to connect the phosphate mining area with the Port of Tampa. Railroad lines in the remaining counties travel primarily north and south, providing access to other points along the Florida peninsula. The railroad network is primarily owned by the Seaboard Coast Line. Minor portions, however, belong to Swift and Company and American Agricultural Chemicals. In the southwestern corner of Polk County, Swift and Company owns approximately 8 miles of track and American Agricultural Chemicals, approximately 6 miles (U.S. Geological Survey 1975; Tampa Electric Company 1979).

2.7.2 HIGHWAYS

Tampa is the major traffic node in the six-county area. Many of the area's major highways either originate in or pass through the city (Figure 2-20). Interstate 4 begins in Tampa and runs east-northeast through Polk County toward Orlando. Interstate 75 originates in Tampa and proceeds north through Pasco County. U.S. 41 follows the coastlines of Manatee and Hillsborough Counties until it reaches Tampa, from which point it continues north through central Pasco County. U.S. 301 parallels U.S. 41 through Manatee County and most of Hillsborough County but veers to the northeast just east of Tampa. U.S. 19 originates north of Palmetto, crosses the mouth of Tampa Bay jointly with I-275 and then proceeds north through Pinellas and Pasco Counties. U.S. 17 heads north through Hardee County and northeast through Polk County. U.S. 92 originates in Pinellas County and runs in an east-northeasterly direction through Tampa and Polk County. State Route 60 begins on the Gulf Coast in Pinellas County and proceeds in an easterly direction through Tampa and into Polk County. State Route 64 follows the same orientation through Manatee and Hardee Counties. Interstate 275 originates in Tampa, heads west into Pinellas County (across old Tampa Bay), and then turns south and proceeds across the mouth of Tampa Bay into the northern half of Manatee County.

2.7.3 AIRPORTS

There are approximately 40 airports in the six-county area, including MacDill Air Force Base. Two of the airports, Tampa International and St. Petersburg-Clearwater International, have precision instrumental approaches. These airports and two others, Sarasota-Bradenton and Albert Whitted, provide the region with commercial air service. Tampa International handles overseas as well as interstate domestic flights. Sarasota-Bradenton also handles interstate flights, while Albert Whitted and St. Petersburg-Clearwater International handle only intrastate flights. The network is integrated by a number of public and private general aviation airports that provide service for smaller, unscheduled aircraft (Tampa Bay Regional Planning Council 1977; Florida Department of Transportation, undated-a, undated-b).

2.7.4 WATERWAYS

The Port of Tampa encompasses all of the water facilities in Hillsborough County. Thus, the port includes the public facilities of Hookers Point and Ybor Channel and the privately owned facilities at Garrison Channel, Port Sutton, East Tampa, East Bay, Sparkman Channel, Port Tampa, and Big Bend (Booz-Allen & Hamilton, Inc. 1979). The dredged channel is 34 feet deep and 400 feet wide in Tampa and Hillsborough Bays, Port Tampa, and Sparkman and Ybor Channels. In Seddon and Garrison Channels, the dredged channel is 30 feet deep and 300 feet wide.

Together, these facilities form the eighth largest port in the United States in terms of total tonnage and the fourth largest in terms of total exports (Tampa Bay Regional Planning Council 1977). The Port of Tampa is a trade and distribution center for the Southern United States, and it has experienced a remarkable increase in activity in recent years. Total tonnage handled at the port has grown from approximately 18 million in 1965 to over 48 million in 1978 (Booz-Allen & Hamilton, Inc. 1979; Stanford Research Institute 1968). Phosphate accounted for 50 percent of the total cargo tonnage in 1978, petroleum was 25 percent, and dry bulk, liquid bulk, and general cargoes were 12, 10, and 3 percent, respectively (Booz-Allen & Hamilton, Inc. 1979). The handling of this cargo contributed approximately $202 million in direct benefits to the port and over $500 million in direct benefits to both the Tampa maritime industry and the Tampa area economy (Booz-Allen & Hamilton, Inc. 1979).

Port Manatee has also experienced significant growth since it began operation 9 years ago. Total tonnage in 1975 averaged 3.5 million tons and projections for 1978 were for an average of 7 million. Trade goods passing through the port include petroleum products, feed, cement, scrap steel, plywood, pipe, waste paper, and offshore drilling materials (Tampa Bay Regional Planning Council 1977).

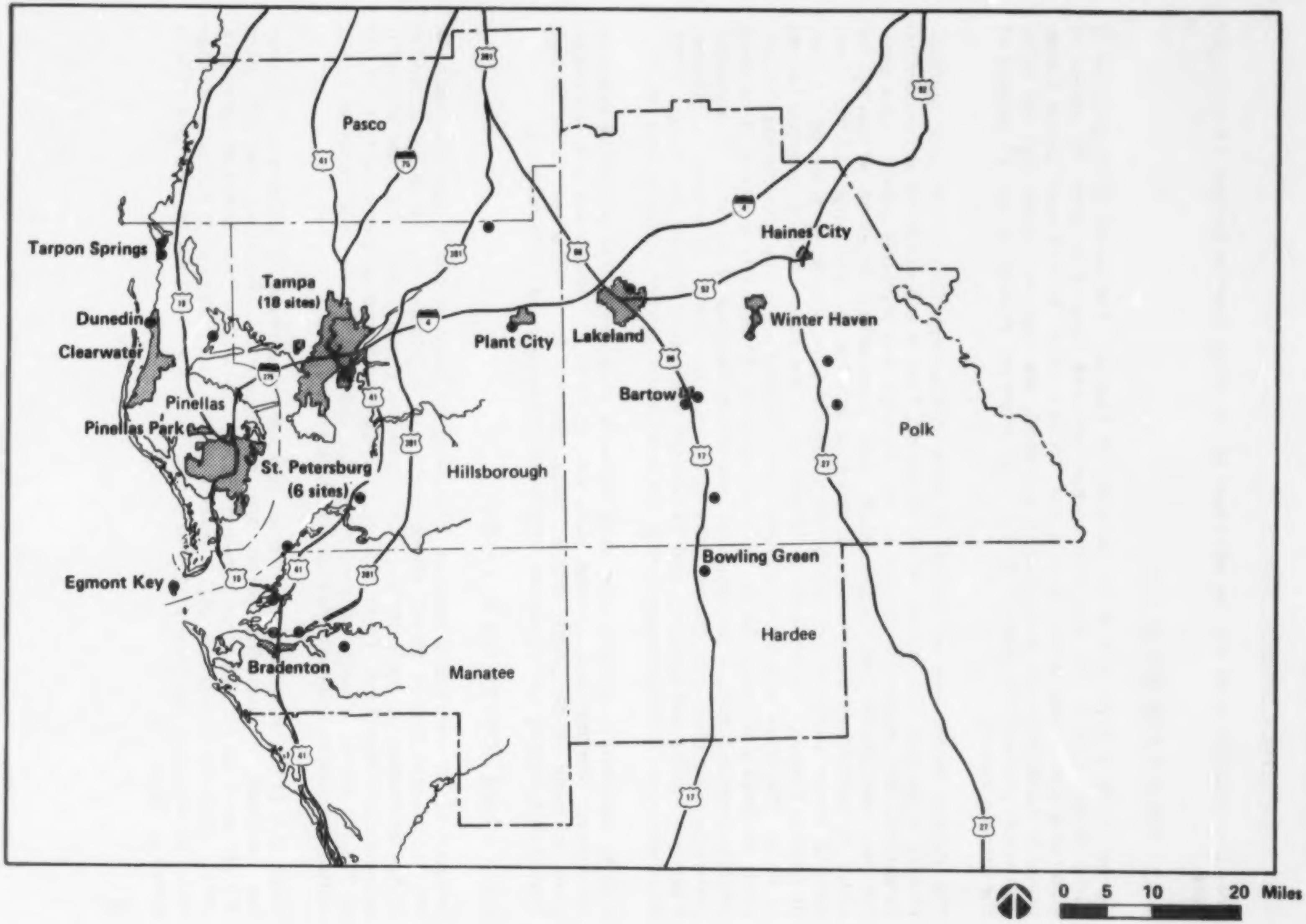

Pasco
Tarpon Springs
Tampa
(18 sites)
Dunedin
Clearwater
Pinellas
Pinellas Park
St. Petersburg
(6 sites)
Hillsborough
Egmont Key
Bradenton
Manatee
Plant City
Lakeland
Bartow
Haines City
Winter Haven
Polk
Bowling Green
Hardee
301
41
75
19
4
275
98
92
17
27
0
5
10
20
Miles

Figure 2-20. Major highways and *National Register* historic sites in the Tampa Bay area.

2.8 SENSITIVE AREAS

2.8.1 SENSITIVE GEOLOGIC AREAS

Sensitive geologic areas will be addressed at the siting level in Section 5.9 at a later date.

2.8.2 FOREST AND WOODLAND

Timber plays a large part in the economy of Florida. The forest products industry ranks second only to the food and kindred products industry in terms of number of employees and annual payroll (Knight and McClure 1970). In 1969 most Florida timber products came from the production of pulpwood, saw logs, and veneer logs and bolts. Softwoods provided 90 percent of the total pulpwood production and 82 percent of the saw-log volume.

The central forest unit of Florida includes Hillsborough County. In 1970 approximately 26 percent (2.7 million acres) of central Florida was classified as commercial forestland, and nearly 90 percent of this acreage was privately owned. Oak-gum-cypress associations and longleaf-slash pine associations together accounted for about 70 percent of the commercial forest stands (Snyder and Knight 1970). Commercial forest statistics for Hillsborough County were similar to those of the rest of central Florida. Approximately 22 percent of the county was commercial forests in 1970. The types of trees in commercial forestland were oak-gum-cypress, 49 percent; longleaf-slash pine, 20 percent; oak-hickory, 20 percent; oak-pine, 5 percent; loblolly-shortleaf pine, 4 percent; and elm-ash-cottonwood, 2 percent. Composition percentages by stand-size classes were 42 percent sawtimber, 24 percent poletimber, 9 percent sapling and seedling, and 25 percent nonstocked (Snyder and Knight 1970). Woodland types in Hillsborough County are described in Section 2.2.4.2 of this report.

County lumbermen normally plan their harvests according to the prevailing moisture conditions. Merchantable cypress, gum, elm, hickory, live oak, water oak, and maple grow on many of the poorly drained sites. During the rainy season (June through September), logging operations are largely restricted to the drier forest sites.

2.8.3 PRIME AGRICULTURAL LANDS

Because of its subtropical climate, Hillsborough County is one of the few places in the continental United States where fruits and vegetables can be grown in winter (U.S. Department of Agriculture 1958). Consequently, the agricultural use of land is economically important. From 1930 to 1950, farmland acreage increased from 98,029 to 398,171 acres. Nearly 60 percent of the farmland was devoted to citrus fruits, winter vegetables, and rangeland for livestock production.

Since the 1950s, however, the overall agricultural acreage of Hillsborough County has declined, as has the percentage of farmland. Farmland declined from 374,767 acres to 358,178 acres between 1969 and 1974 (U.S. Department of Commerce 1974). This was a decrease of 2.5 percent (56.4 to 53.9 percent) of the total acreage (664,192 acres) of the county at that time. Land use on farms in 1969 and 1974 is shown in Table 2-58.

Among soil mapping units, Blitchton soil is the only category designated as prime farmland soil in Hillsborough County (J. Miller, Soil Conservation Service, personal communication). No prime farmland soils occur on the TECO site.

2.8.3.1 Types and Sizes of Farms

In 1969 slightly less than 50 percent of the Hillsborough County farms had sales of $2,500 or more. By 1974 the percentage of farms with sales of $2,500 or more had increased to 56.9 percent. From 1969 to 1975, the average size of these farms had increased from 237 acres to 246 acres. Farms with incomes below $2,500 also increased in average size (from 135 acres to 153 acres) during the period 1969-1975.

From 1950 to 1974, the total number of farms continued to decrease. Of the 3,753 farms inventoried in Hillsborough County in 1950, 2,030 were classified by type (U.S. Department of Agriculture 1958). The total number of farms declined from 2,769 in 1969 to 2,335 in 1974.

Vegetable farms, citrus groves, poultry farms, and cattle ranches are the main ventures in most of the agricultural areas of the county. Most of the citrus groves are small (20 to 25 acres), and they sometimes occur on larger farms in conjunction with other agricultural activity. Cattle ranches often occupy parcels of 1,000 acres or more. The acreage allotted to vegetables varies with the type of crop.

2.8.3.2 Crops

Hillsborough County produces a variety of winter vegetables for the markets in the populous Northeastern United States. The principal crops include tomatoes, strawberries, peppers, sweet corn, snap beans, green lima beans, cucumbers, squash, and watermelons. Tree fruits include oranges, grapefruit, and tangerines. Lemons, limes, avocados, peaches, and grapes are also grown.

2.8.3.3 Crop Productivity

With good management, which includes yearly fertilization and water control techniques, crop productivity in Hillsborough County is high for most crops. The natural vegetation of range grasses and forestland has a growth potential that ranks only poor to fair.

2.8.4 HABITATS OF RARE AND ENDANGERED SPECIES

2.8.4.1 Flora

Not one of the plant species in Hillsborough County is designated or proposed as threatened or endangered (41 FR 199, 24,524-24,572; Smithsonian Institution 1975; Ayensu and DeFilipps 1978). Moreover, not one of the Hillsborough County plants is cited by the Florida Committee on Rare and Endangered Plants and Animals (FCREPA 1976). However, Long (1975) reported the saw palmetto (*Serenoa repens*) as a protected species. Nevertheless, the Environmental Protection Commission of Hillsborough County considers 11 habitat types worth protecting because they play a part in the preservation of good water quality (E. R. Tobi, Environmental Protection Commission of Hillsborough County, personal communication). The following is a list of these 11 habitat types:

1. Saltwater aquatic wetland--Wetland dominated by free-floating, rooted, or otherwise attached aquatic herbs and permanently flooded with brackish or saline water

   Dominant species: Syringodium filiforme, Halodule wrightii, Thalassia testudinum, Ruppia maritima

2. Saltwater coastal flat--Wetland with 25 percent or less vegetative cover; occasionally or regularly flooded with saline water of tidal origin; usually exists in hypersaline and intertidal areas

   Dominant species: Halodule wrightii, Ruppia maritima, Salicornia perennis, S. virginica, Sesuvium portulacastrum, Suaeda linearis, S. maritima

3. Saltwater marsh--Wetland with more than 25 percent vegetative cover in the form of herbaceous plants but with 40 percent or less woody plant cover; occasionally or regularly flooded by brackish or saline water

   Dominant species:

   a. Shallow phase: Juncus roemerianus, Batis maritima, Acrostichum aureum, Conocarpus erecta, Distichlis spicata, Sporobolus virginicus, Spartina alterniflora, Fimbristylis castanea

   b. Deep-water phase: Juncus roemerianus, Batis maritima, Monothochloe littoralis, Spartina alterniflora, S. bakerii, Borrichia frutescens, B. arborescens

4. Saltwater swamp--Wetland with more than 40 percent cover in the form of woody plants; occasionally or regularly flooded with brackish or saline water.

   Dominant species: Rhizophora mangle, Avicennia germinans, Laguncularia racemosa

5. Cypress swamps--Shallow depressions, or areas along sloughs, rivers, and lakes subject to inundation by storm-water runoff (which can vary from seasonal to regular occurrences), and dominated by an arboreal community

   Dominant species: Taxodium distichum, T. ascendens, Magnolia virginiana, Gordonia lasiantha, Nyssa biflora, Acer rubrum

6. Bay swamps--Shallow depressions, or areas along sloughs, rivers, and lakes; subject to inundation by storm-water runoff (which can vary from seasonal to regular occurrences), and dominated by an arboreal community

   Dominant species: Magnolia virginiana, Gordonia lasiantha, Persea borbonia, Nyssa biflora, Acer rubrum

7. *Gum swamps*--Shallow depressions, sloughs, rivers, and lakes; subject to inundation by storm-water runoff (which can vary from seasonal to regular occurrences), and dominated by an arboreal community

   Dominant species: *Nyssa biflora*, *Nyssa aquatica*, *Magnolia virginiana*, *Acer rubrum*, *Gordonia lasiantha*

8. *Shallow grassy ponds*--Very frequently flooded depressions with infrequent fires

   Dominant species: *Cyperus* spp., *Panicum* spp., *Sagittaria latifolia*, *Pontederia lanceolata*, *Nymphaea odorata*, *Typha* spp.

9. *Freshwater marshes*--Shallow depressions frequently flooded by storm-water runoff and dominated by grasses and sedges

   Dominant species: *Cyperus* spp., *Panicum* spp., *Hypericum* spp., *Lachanthes caroliniana*, *Xyris platylepis*

10. *Hydric hammock*--Arboreal community along sloughs and rivers which is seasonally flooded; dominated by deciduous trees

    Dominant species: *Nyssa biflora*, *Sabal palmetto*, *Magnolia virginiana*, *Carya aquatica*, *Fraxinus caroliniana*, *Taxodium ascendens*

11. *Lakes, ponds, and rivers*--Bodies of water with free-floating and/or submergent and emergent macrophytes; may be contiguous with cypress swamps, bay swamps, gum swamps, and hydric hammocks

    Dominant species: *Panicum hemitomon*, *P. purpurescens*, *P. repens*, *Nymphaea odorata*, *Pontederia lanceolata*, *Sagittaria latifolia*

2.8.4.2 Fauna

The endangered species program in Florida is one of the largest in the United States. The Florida Game and Fresh Water Fish Commission (FGFWFC) currently lists 99 species of terrestrial and aquatic vertebrates (24 amphibians and reptiles, 33 birds, 26 mammals, and 16 fishes) and three species of terrestrial invertebrates as endangered, threatened, or worthy of special concern (Florida Game and Fresh Water Fish Commission 1979). All of these are in some way protected by the state. Thirty-five of these species are also listed by the Federal Government as threatened or endangered (44 FR 12, 3,636-3,654).

The Florida Committee on Rare and Endangered Plants and Animals (FCREPA 1976) currently lists 213 species of terrestrial and aquatic vertebrates, including 57 mammals (21 cetaceans), 69 birds, 45 amphibians and reptiles, and 42 fishes, as well as 47 aquatic and 8 terrestrial invertebrates, as endangered, threatened, rare, species of special concern, or species of undetermined status. Of these 268 species, only the 98 that are also listed by the FGFWFC are fully or partially protected by law.

2.8.4.2.1 Aquatic Species

2.8.4.2.1.1 Invertebrates

No aquatic invertebrates occurring in Florida have status on Federal or state listings (44 FR 12, 3,636-3,654; Florida Game and Fresh Water Fish Commission 1979). However, the Florida Committee on Rare and Endangered Plants and Animals (FCREPA 1976) lists 29 freshwater and 18 marine species as having special status. Two of the marine species, the mangrove crab and the Atlantic geoduck, have been reported from the Tampa Bay area (Table 2-59). The following are accounts of the distribution and habitat preferences of these two species.

Mangrove Crab

The mangrove crab (Brachyura: Grapsidae) is considered threatened by the FCREPA (1976). This species ranges from the Tampa Bay and Indian River regions throughout southern Florida. It is found among the roots and especially on the branches of mangrove trees (particularly the red mangrove) along estuarine to nearly freshwater shorelines. It may also be found occasionally on wharves and pier pilings in estuarine and marine areas. Ovigerous females are found in Florida from early spring through summer. This species is widely distributed throughout the Caribbean Sea and along the eastern Pacific coastline, but, being dependent on mangroves, it is found in the continental United States only in Florida. Local populations may be placed in jeopardy when mangrove areas are destroyed in the process of land development.

Atlantic Geoduck

The Atlantic geoduck clam (Pelecypoda: Hiatellidae) is considered rare by the FCREPA (1976). The species has been collected very infrequently from most areas of the Carolinian geographic province (North Carolina to Texas). In various parts of its range, it occurs in depths from the intertidal zone to as deep as 48 meters. In Florida, living specimens are known with certainty only from Duval and St. Johns Counties on the northeast coast. Robertson (1963) listed numerous dead shell records from North Carolina to Cape Canaveral on the Atlantic coast and from Sanibel Island to Tampa Bay and from Panama City to southwest Texas in the Gulf of Mexico. Nearly all were beach collections, but the occurrence of single dead pairs was recorded from a location approximately 33 kilometers north of Cape Hatteras (depth unknown) and from an area northeast of Port Isabel, Texas, in approximately 55 meters of water. More recent collections along the Florida west coast have produced dead shell off Cape Romano, in Charlotte Harbor, in St. Joseph Bay, and at Pensacola. It is difficult to decide how indicative dead shell occurrence may be of living distribution. Most shells in recent collections are old and worn, and none have been subjected to dating analysis. They could represent once viable populations, no longer present in certain areas, whose shells are now being exposed by erosional action associated with the rising sea level.

Very little is known of the life history and ecology of the Atlantic geoduck. Robertson (1963) speculated that the usual habitat of the species may be subtidal, but that specimens rarely would be obtained alive below the tidal zone because of the depth at which they normally live buried in the sediment. He suggested that living subtidal specimens have all been obtained under exceptional circumstances. Intertidal specimens have been found buried in mud at depths of 46-76 centimeters (FCREPA 1976) and even as deep as 122 centimeters (Johnson 1956). Two of the three instances of offshore collection of living specimens followed natural or man-made disturbances (i.e., a hurricane off the northeast coast of Florida and oil drilling activities off Texas). The few beached specimens from North Carolina were beached by storms. Except for one offshore collection, all living specimens collected in Florida waters have been found in estuarine environments near inlets in Duval and St. Johns Counties. In addition, a freshly dead hinged-shell pair was dredged from the estuarine environment of St. Joseph Bay, Gulf County.

2.8.4.2.1.2 Fishes

Forty-two extant fish species are given special status by the Florida Committee on Rare and Endangered Plants and Animals (FCREPA 1976). Fifteen of these plus one additional species (alligator gar) are on the current State of Florida list of endangered and potentially endangered species (Florida Game and Fresh Water Fish Commission 1979). Two of these species also have Federal status (44 FR 12, 3,636-3,654). Four of the 42 fishes listed by the FCREPA have been reported from the Tampa Bay area (Table 2-60), and two of these, Atlantic sturgeon and Rivulus, are also listed by the state as species of special concern. The distribution and habitat preference of the four FCREPA-listed species are described in the following sections.

Atlantic Sturgeon

The southern subspecies of the Atlantic sturgeon, Acipenser oxyrhynchus desotoi (family: Acipenseridae), occurs primarily in the northeastern Gulf of Mexico. While it is likely that this subspecies once occurred in a broader range, recent records indicate its present range in the Gulf of Mexico extends from west-central Florida (Tampa Bay) to eastern Louisiana (Vladykov 1955; Vladykov and Greeley 1963; Huff 1975). The Atlantic sturgeon is an anadromous species, spawning in brackish water or freshwater but achieving most of its growth in oceanic waters. This is a bottom species, typically closely associated with estuaries but occasionally migrating to offshore waters. Migrations to brackish water or freshwater spawning sites (typically over hard bottom) occur from early March to May in the Suwannee River, and peak activity occurs in April. Observations in the Suwannee River indicate that sturgeon may begin anadromous migrations as yearlings.

There is a limited commercial fishery for sturgeon in the lower Suwannee River that has apparently remained fairly stable (Huff 1975). However, populations of the species are severely depleted or absent in some areas where they once occurred. Tampa Bay was the site of the first active sturgeon fishery in Florida. This short-lived fishery operated only during the winters of 1886-1889 and was then abandoned because of stock depletion. Occasional sightings of sturgeon and captures of individuals have been reported in the Tampa Bay area since that time.

The FCREPA (1976) lists Atlantic sturgeon as a threatened species because of its protracted maturation period (7-9 years for males and 8-12 years for females, in the Suwannee River) and its dependence on large river systems. Because sturgeon cannot reestablish breeding populations as rapidly as can most fishes and because of the potential for diversion from spawning runs upriver due to pollution effects, this species is regarded as vulnerable.

Rivulus

Rivulus marmoratus (family: Cyprinodontidae) is the only species of the genus found in North America (Florida Committee on Rare and Endangered Plants and Animals (FCREPA 1976). The species is known to occur in Cuba, in the Bahamas, on scattered islands in the West Indies, and on islands off the coast of Venezuela. In the continental United States, it is known only from the southern third of peninsular Florida. In Florida, Rivulus has been collected only from "anti-mosquito ditches" and from bays associated with estuarine mangrove or salt marsh shorelines. Conditions at sites of collection have been characterized as follows: water depth, 1-2 feet; water color, milky or opaque; salinity range, 20-32 parts per thousand; bottom material, marly muck; and aquatic vegetation, usually absent. On at least one occasion, individuals were seen utilizing crab holes as hiding places (Harrington and Rivas 1958; Thomerson 1966).

Most Rivulus collected from Florida waters have been synchronous, self-fertilizing hermaphrodites (Harrington 1961, 1971). Male fish (gonochorists) are rare and of two types: primary males that develop directly from fertilized eggs without going through the hermaphroditic phase; and secondary males that develop from hermaphroditic fish under certain ecological and experimental conditions. Normal biparental reproduction has not been demonstrated for the Florida populations but has been reported in the West Indies. Sexual maturity is reached at an age of approximately 3 months, by which time the individuals have attained a length of approximately 20 millimeters (one-third of maximum length).

Rivulus marmoratus has been collected a total of only seven times in Florida. The collections occurred in Key West, Miami, Biscayne Bay, St. Petersburg, and in the Indian River in the vicinity of Ft. Pierce. All collections have been small; most were less than five individuals, and the largest included only 22 specimens. Because of its unique mode of reproduction, this species is apparently able to persist with very low population densities. Its rarity and apparent secretive behavior make it difficult to assess the distribution and status of this species in Florida. Although there is no direct evidence that the species is endangered in the state, its habitat (estuarine boundaries) is vulnerable to development and other types of destruction. The FCREPA, therefore, has included this species on listings of threatened fishes of Florida.

Opossum Pipefish

The opossum pipefish (family: Syngnathidae) is classified as rare by the FCREPA (1976). This species has been recorded in brackish water and freshwater habitats from the southeastern United States to southern Brazil. It has an extremely spotty distribution throughout its range in the western Atlantic, having been recorded from South Carolina, Georgia, Florida (six separate localities), Alabama, Mississippi, Cuba, Puerto Rico, Costa Rica, Panama, Colombia, and southern Brazil. On the east coast of Florida, it has been recorded from the lower St. Johns River, Anastasia Island, the vicinity of Vero Beach, the Loxahatchee River estuary, and Jupiter Inlet. The only record from the Florida Gulf coast is a single immature specimen taken adjacent to the mouth of Tampa Bay (Powell, Dwinell, and Dwinell 1972). The species has also been recorded from Dauphin Island, Alabama, and from the Mississippi coast. The record from Vero Beach is from freshwater, while all others are from brackish water.

The opossum pipefish lives in fresh and estuarine waters, frequently in association with dense, submergent aquatic vegetation. Very little is known of the life history and ecology of this species. All records have been from inshore areas and apparently no specimens have been reported from plankton collections, including samples containing floating masses of *Sargassum*. However, its wide and apparently scattered distribution, both in insular and coastal areas, suggests that ocean currents are probably the primary means of dispersal.

Since the opossum pipefish has been recorded so few times in Florida, despite numerous collections from seemingly suitable habitats, it is classified as rare. However, in view of its wide distribution and the fact that so little is known regarding its life history, it is not considered as threatened in the state at the present time.

Mountain Mullet

The FCREPA (1976) lists the mountain mullet (family: Mugilidae) as rare in Florida waters. The range of this species includes the southern United States (north at least to Georgia), Mexico, Central America, the West Indies, and northern South America at least to Colombia and Venezuela (Suttkus 1956). Its distribution in the United States is scattered, as it perhaps is in other areas. The young of this species are found well out to sea (Anderson 1957). Subadults and adults ascend tropical and subtropical streams, often to the extreme headwaters (Gilbert and Kelso 1971). The FCREPA (1976) reports this species as having been collected in Pinellas County.

Although the spawning site of mountain mullet has not been specifically determined, there is circumstantial evidence that this species is one of the relatively few catadromous fishes. The presence of very young stages well out to sea and the relatively large size of individuals taken in freshwater environments suggest that the species spawns at sea but spends the remainder of its life in freshwater. It is not known whether the adults return to the same freshwater stream after each spawning episode or even if individuals spawn more than once. It is unlikely that young return to the same stream inhabited by the parents, particularly since very young individuals have been found drifting hundreds of miles from shore. Although the mountain mullet certainly qualifies as a rare species, due to the infrequency of occurrence, it is not considered threatened because of its catadromous habits and its independence from any one stream or stream system.

2.8.4.2.1.3 Aquatic Mammals

Florida (West Indian) Manatee

The Florida or West Indian manatee is individual on both Federal (44 FR 12, 3,636-3,654) and State of Florida (Florida Game and Fresh Water Fish Commission 1974) endangered species lists (Table 2-44). In addition, the manatee is protected by the Marine Mammal Protection Act of 1972 (16 U.S.C. 1361).

In Florida, the manatee occurs along the Atlantic and gulf coasts of the Florida Peninsula. It also appears in Georgia during certain seasons and rarely in South Carolina. On the gulf coast of Florida, the manatee's range is continuous from Whitewater Bay to Charlotte Harbor, with semi-isolated populations in Hillsborough, Citrus, and Levy Counties. The area of greatest abundance on the gulf coast extends from Charlotte Harbor through the Ten Thousand Islands. From 1971 through 1973, manatees were reported in Hillsborough County in coastal areas, in Hillsborough Bay, and in the Litle Manatee, Alafia, and Hillsborough Rivers. Winter congregations have also been reported from the Big Bend Generating Plant (Hartman 1974). They are considered relatively common along the eastern shore of Tampa Bay, where the population is estimated to be 30 individuals. The U.S. Department of the Interior has listed the Little Manatee River below Route 301 as critical habitat for manatees in Hillsborough County (Section 5.3.4.6.1).

The primary habitats of the manatee are sluggish rivers, shallow estuaries, and saltwater bays. Populations are concentrated in estuarine and riverine habitats, especially spring-fed rivers. Primary habitats include areas with (1) vascular aquatic vegetation, (2) proximity to channels at least 2 meters deep (approximately 6.56 feet), (3) warm water during cold winter periods, and (4) a source of freshwater. They are known to seek the warm water of powerplant discharges in the winter.

From 750 to 850 (maximum 1,000) manatees are believed to exist in the United States. The gulf coast population is estimated to be from 350 to 400. Primary factors for projected population decreases are (1) propellers of power boats, (2) vandalism, (3) poaching, and (4) habitat destruction.

Cetaceans (Whales and Dolphins)

Twenty-one species of cetaceans have geographic ranges that could include Tampa Bay and adjacent waters of the Gulf of Mexico (Table 2-44). Of these, seven whales species are listed as endangered by the Federal Government (44 FR 12, 3,636-3,654) and the State of Florida (Florida Game and Fresh Water Fish Commission 1979). In addition, all cetaceans are protected by the Marine Mammal Protection Act of 1972 (16 U.S.C. 1361). Only the battle-nosed dolphin, Tursiops truncatus, is expected to occur in the area with any regularity (Section 5.3.4.6.2).

2.8.4.2.2 Terrestrial Species

2.8.4.2.2.1 Invertebrates

Although the status of terrestrial invertebrates in Florida is poorly known (Layne et al. 1977), several species are given special status (i.e., endangered, threatened, or species of special concern) by the United States Department of the Interior (USDI), the Florida Game and Fresh Water Fish Commission (FGFWFC), and the Florida Committee on Rare and Endangered Plants and Animals (FCREPA) (Table 2-61).

Three species of invertebrates have been given special status by the USDI and the FGFWFC, and two species are under review by the USDI (45 FR 99, 33,768-33,781; Florida Game and Fresh Water Fish Commission 1979). The Stock Island tree snail, Bahama swallowtail butterfly, and Schaus swallowtail butterfly are considered threatened, while the Florida tree snail and Atala butterfly are under review by the USDI (Table 2-61). No critical habitat has been determined for these species (45 FR 99, 33,768-33,781). The Florida tree snail occurs in hammocks in southern Florida. The status of the Atala butterfly is unknown.

The Bahama swallowtail butterfly occurs mainly in the Bahamas, but occasionally it is found in the Biscayne National Monument south of Miami (Bentzien, U.S. Fish and Wildlife Service, Endangered Species Office, personal communication, August 4, 1980). The Schaus swallowtail butterfly occurs primarily in Dade and Monroe Counties and in the Biscayne National Monument. Both species could occur on islands in the Florida Keys. These butterflys feed on citrus trees and shrubs (family: Rutaceae) among the tropical hardwoods in hammocks. The Stock Island tree snail occurs only in hammocks in the Florida Keys (F. Thompson, Florida State University, State Museum, Malacology Section, personal communication, August 4, 1980).

The FCREPA lists eight additional species of terrestrial invertebrates, including one spider and seven beetles (Layne et al. 1977; Table 2-61). These species are listed because habitats in which they live are becoming scarce or because vertebrate hosts on which they depend are becoming less common.

The gopher tortoise copris beetle, peninsular gopher tortoise dung beetle, gopher tortoise aphodius beetle, and southwest Florida wingless burrowing beetle are all considered threatened by the FCREPA (Layne et al. 1977). The three gopher tortoise beetles are threatened because of their close association with the gopher tortoise, also listed as threatened. The wingless burrowing beetle occurs in "scrub islands" and could occur in Hillsborough County.

The Abott's purse-web spider is a species of special concern. It inhabits mesic woods from central peninsular Florida into Georgia and it could occur in the Big Bend region.

Three scarab beetles (Table 2-62) are classified as "status undetermined" because information on their distribution, abundance and habitat preference is scarce. Aphodius and Peltotrupes have been reported in Hillsborough County. Aphodius lives only in pocket gopher burrows. Distribution and abundance of Copris is largely unknown.

2.8.4.2.2.2 Amphibians

No amphibians have Federal status in Florida (44 FR 12, 3,636-3,654). The FGFWFC lists 2 species of amphibians as having special status. The FCREPA lists 10 species (McDiarmid 1978). The Florida crawfish frog (i.e., Florida gopher frog) is the only species on both the FGFWFC and FCREPA lists that could occur on or near the Big Bend site.

Florida Crawfish Frog

The Florida crawfish frog is considered to be a species of special concern by the FGFWFC and as a threatened species by the FCREPA (Table 2-62; Florida Game and Fresh Water Fish Commission 1979; McDiarmid 1978). This species is found throughout the northern part of the state. In central Florida it is restricted to the Lake Wales Ridge and coastal xeric habitats. The crawfish frog is found in sand-hill communities, on bluejack and turkey oak ridges, and in sand pine scrub habitats. It commonly shares gopher tortoise burrows. Habitat destruction will continue to affect this species. It is not expected to occur on the Big Bend site because suitable habitat is lacking there.

2.8.4.2.2.3 Reptiles

Thirty-five reptiles are given special status by the FCREPA (McDiarmid 1978). Twenty-two of these are on Florida's current list of endangered or potentially endangered species (Florida Game and Fresh Water Fish Commission 1979). Thirteen of these 22 species have Federal status (44 FR 12, 3,636-3,654). Nine of these 35 special status species could occur on or near the Big Bend site (Table 2-62). These include 1 turtle species, 1 tortoise species, the alligator, 2 snake species, and 4 sea turtle species. Eight of these have Federal status.

Species Accounts: Distribution and Habitat Preference

River Cooter (Suwannee Cooter). The Suwannee cooter, a subspecies of the river cooter, occurs along the west coast of the Florida peninsula south to the Alafia River. It is absent from most small rivers whose headwaters are below 7.6 meters in elevation.

This subspecies is generally restricted to rivers and spring runs draining into the Gulf of Mexico. It is most common near heavy growth of Najas and Sagittaria, including grassy flats of river mouths. It can be found in freshwater and saltwater. Presently, this subspecies is known to occur in Hillsborough County only in the Alafia River. It is not expected to occur on the Big Bend site. The decline in the Suwannee cooter population in recent years may be a result of boating accidents, utilization as food by man, habitat destruction, and river pollution.

Gopher Tortoise. This species occurs in suitable habitat from Cape Sable and Cutler Ridge northward along both coasts to the general latitudes of Sarasota and Fort Lauderdale. From there northward, the species is widely distributed in suitable habitat over the entire peninsula. It prefers dry, well-drained soils. It inhabits beach scrub, sand pine, longleaf pine-turkey oak hammocks, live oak hammocks, and old fields in early successional stages. The long and deep burrows used by this species during unfavorable climatic conditions also house other terrestrial vertebrates, including the pine snake, indigo snake, Florida mouse, and gopher frog. The gopher tortoise population has remained fairly stable in central parts of the peninsula, but has declined in the west, south, and the citrus belts. Habitat destruction is the greatest problem facing this species. The species could occur on the Big Bend site.

American Alligator. The alligator occurs in suitable habitat throughout Florida. It is more common, however, on the peninsula than in the panhandle. It is distributed in various wetlands of the state, including edges of large lakes and ponds, rivers, the interiors of swamps and freshwater marshes, and sometimes in brackish water or saltwater. It can live near human disturbance. Alligator holes help produce vegetation that is important for the nest sites of several avian species. These holes are also important for wildlife during droughts. Alligators may occur on the Big Bend site, but their numbers would probably be low because of limited suitable habitat.

Eastern Indigo Snake. This subspecies occurs only in the Southeastern United States. The major part of its range is in Florida. It is characteristic of moist habitats in pine flatwoods and tropical hammocks. It also occurs in drier, sandy areas and in pine communities. In drier areas it seeks out gopher tortoise burrows. Snake collecting and the reduction in gopher tortoise populations are the primary reasons for the decline of this subspecies. This subspecies is expected to occur in low numbers on the Big Bend site.

Short-Tailed Snake. This species is endemic to Florida. It occurs mostly in the north-central part of the state westward to the gulf coast counties, excluding the panhandle. It is restricted to longleaf pine-turkey oak associations, although it can occur in adjacent habitats such as upland hammocks and sand pine scrub. Soil type may be a more limiting factor than habitat. Norfolk, Blanton Fine, and St. Lucie are the preferred soil types, which usually occur in the longleaf pine-turkey oak region. Most of the preferred habitats and also the largest populations of this snake occur in Marion and Lake counties, with isolated populations elsewhere. The species is seriously affected by the destruction of longleaf pine-turkey oak stands in preferred soil types. It is not expected to occur on the Big Bend site.

Sea Turtles. Four sea turtles (i.e., Atlantic loggerhead, Atlantic green turtle, Atlantic leatherback, Atlantic Ridley) could occur in gulf coast waters near Hillsborough County. The green turtle, leatherback, and Ridley are considered endangered by the Federal Government and the FGFWFC. The Atlantic loggerhead is considered threatened by both.

More than 90 percent of the United States population of Atlantic loggerheads nest in Florida, mostly on the Atlantic coast. The species is not expected to occur within Tampa Bay, and nesting is not expected near the Big Bend site.

The Atlantic green turtle population in Florida is estimated at 50 mature females. Nesting areas coincide with those of the Atlantic loggerhead on the Atlantic coast of Florida. It may occur in offshore waters near Tampa Bay, but is not expected to occur near the site.

The mature Atlantic Ridley is restricted mostly to the Gulf of Mexico, with most of the population nesting in Mexico. The world population is estimated to be 3,000 to 5,000 mature females. Excessive meat hunting, egg collecting, and commercial fishing accidents are responsible for its population decline. Immature Ridleys could occur in Tampa Bay.

The Atlantic leatherback rarely nests in Florida, and when it does, it does so mostly on the Atlantic coast. This wide-ranging species, which also inhabits colder waters, might occur rarely in Tampa Bay.

2.8.4.2.2.4 Summary

Of the amphibians and reptiles discussed, only the Indigo snake is likely to occur on the Big Bend site with any regularity. It prefers moist pine flatwood habitats. The Indigo snake has been reported on the site in the Myrica-Baccharis association.

Two other reptiles may occur on the Big Bend site. The gopher tortoise may occur occasionally in drier areas such as dunes, salt prairies, old fields, and pine flatwoods.

Although alligators may occur on the site, their status would be questionable because of the unavailability of sufficient wetland habitats.

No sea turtles are expected to nest on the Big Bend site. Immature Atlantic Ridleys could occur near estuarine habitats, probably near the mangrove swamps. Other species might occur in Tampa Bay, but only rarely.

2.8.4.2.3 Birds

Approximately 370 species of birds have been reported in west-central Florida. Of these, 303 have been documented in Hillsborough County. Thirty-three (40 percent) of 83 vertebrate species other than fish listed by the FGFWFC (1979) are birds, and 69 (40 percent) of 171 vertebrate species other than fish listed by the FCREPA (Kale 1978) are birds. Forty-two species with special status, as listed by the FCREPA, have ranges that include Hillsborough County (Table 2-63). Twenty of these 42 species are given special status by the FGFWFC, and four of these are federally protected.

Species having special status in Florida include water birds and land birds. The water birds include shorebirds, larger wading birds, gulls, terns, and their allies. Land birds include all other birds that live, breed, or feed primarily on land. Two species (i.e., bald eagle and osprey) could be considered as land birds (nesting) and waterbirds (feeding). No species of waterfowl is given special status in Florida.

Twenty-six of the special-status species (FCREPA) that could occur in Hillsborough County would be considered waterbirds. All of these are expected to breed in suitable habitats in the region except the piping plover; it is expected to occur in the region only in winter. Fourteen of the 42 species would be considered land birds. All of these would be expected to breed in the region, except the peregrine falcon (transient) and white-tailed kite (irregular).

2.8.4.2.3.1 Species Accounts: Distribution and Habitat Preference

Only those species that are federally protected or that have been given special status by the FGFWFC will be thoroughly discussed. Other species on the FCREPA list are discussed less thoroughly.

Wood Stork

Approximately 20 known colonies exist in peninsular Florida. These are distributed from Duval and Alachua Counties south to the Everglades. They nest primarily in large rookeries in cypress or mangrove swamps, and feed in freshwater marshes, flooded pastures, and ditches. A maximum of 12,000 nesting pairs was reported in 1975. Reportedly, a breeding colony exists in northern Hillsborough County, but this is not near the site. Mangrove swamps and adjacent estuarine areas are important habitats for any wood storks that might occur on the Big Bend site. Water fluctuations, which reduce food availability in primary feeding habitats, are the main reason for the rapid decline of the species from 75,000 birds in the early 1930s. It probably occurs on the Big Bend site, but does not nest there.

Peregrine Falcon

Some peregrine falcons are known to winter in Florida each year where sufficient food is available. Winter habitat includes coastal areas, especially mangrove swamps, where flocks of wintering birds (prey species) congregate. It is considered a rare migrant or very rare winter resident in the region.

Cuban Snowy Plover

This subspecies breeds on the outer beaches and sand bars from Texas to Florida in sparse and scattered locations. It requires expansive, open, dry, sandy beaches for breeding, and dry and tidal sand flats for feeding. It is the only Florida bird that breeds and feeds in open dry sand. Probably less than 100 pairs exist in Florida today. It is not expected to breed in the Tampa Bay area.

Red-Cockaded Woodpecker

Its primary distribution in Florida is the coastal plain pine flatwoods, especially where stands of longleaf pine occur. Its primary habitat is mature to overmature pines. Longleaf pine is preferred, but loblolly, shortleaf, slash, and pond pine are also used. Removal of large mature trees during logging is the greatest threat to the species. Although some habitat may exist for this species on the Big Bend site, it is not expected to occur there.

Eastern Brown Pelican

This species breeds from North Carolina through the Gulf States. The present adult breeding population in Florida is estimated at 6,000 to 8,000 pairs, with a total population of about 30,000 birds. From 50 to 350 breeding pairs of brown pelicans nested at Bird Key in Hillsborough County from 1970 through 1976. In addition, the Alafia Banks colony has over 500 pairs. The Florida population is stable at present. They nest primarily in mangrove trees, from 2 to 35 feet above tide line. Nesting is confined to coastal islands. Fishing line is a great threat to the species. Brown pelicans are not known or expected to nest on the Big Bend site, although feeding or wandering individuals may be fairly common.

Southern Bald Eagle

The original breeding population of eagles in Florida must have been more than 1,000 pairs. Now the eagle is absent or rare along the populated Florida coast and is decreasing generally throughout the state. From 1972 through 1975, there were 274 active nests in the state. The total breeding population may be 325 pairs. About 61 percent of the nests in the state are in pines, with only 23 percent in mangroves. In west-central Florida, a concentration of nesting eagles occurs from Hillsborough County north to southern Levy County. From four to seven pairs are believed to exist in Hillsborough County. Approximately six other breeding concentrations are believed to occur in the state. The species is mostly riparian and is associated with the coast, lakes, or rivers. They usually nest near large bodies of water, but some interior nests exist. No nests are known to exist in the immediate Big Bend vicinity.

Southeastern Sparrow Hawk

This subspecies, an uncommon-to-rare permanent resident in Florida, occurs from South Carolina to southern Florida in the United States. The eastern American kestrel, however, is an abundant winter resident. In Florida, the southeastern sparrow hawk prefers open pine forests and clearings with dead trees. It can be found along open edges of river bottoms, in coastal regions, in suburban areas, and even in cities. The number of these hawks has apparently declined in parts of central and southern Florida. Loss of nest sites may be aiding this decline. This species is becoming extremely rare in the state as a breeder, and it is unlikely that it would occur on the Big Bend site.

Audubon's Caracara

In Florida, this species is largely restricted to the prairie areas of the south-central peninsula region. In west-central Florida, it is more common in the prairie areas of Charlotte, DeSoto, and Hardee Counties (Layne et al. 1977). This is an open-country bird. Dry prairies with cabbage palm and with some wet areas are preferred. It will occur in pasturelands and in wooded areas with scattered grasslands. The minimum population in the state between 1973 and 1975 was 350 individuals. Habitat destruction is the greatest enemy of the species. This species does not breed on the site, but could occur in the area as a rare transient or summer visitor.

Florida Sandhill Crane

This Florida subspecies occurs as a permanent resident throughout the peninsula, the statewide population being 4,000 to 6,000 (Sanderson 1977). It should not be confused with the greater sandhill crane, which is a winter resident. Field identification of these two subspecies is difficult. The Florida sandhill crane prefers wet prairies, marshy lake margins, cattle pastures, marshes, and shallow flooded areas. It does not readily stay near human disturbance. It nests in the shallow water of lakes, ponds, and open marshes. Breeding has been reported in Hillsborough County. Draining of wetlands is a major reason for its slow decline. It is not expected on the Big Bend site because of habitat restrictions.

American Oystercatcher

The resident population in Florida is joined by migrating individuals in the winter. Although scattered nesting occurs along both coasts, the majority probably nest on the gulf coast. This species is known to nest and winter in Tampa Bay. It is restricted to broad, open coastal beaches, mudflats, and spoil islands. Development of coastal areas aids in the decline of this species as a breeder. It could possibly breed on the site, especially on spoil areas, but would more likely occur as a visitor, both in summer and winter.

Least Tern

This species has a world-wide distribution. In the Eastern United States, it breeds along the coast from Louisiana to the Dry Tortugas and northward to Maine. It prefers open, flat beaches with coarse sand or shell, but also occurs inland. It will also use dredge-and-fill spoil areas. The species is threatened by beach development. It nests within Tampa Bay, sometimes on spoil areas or rooftops. The least tern could nest on the site and almost certainly occurs there as a visitor.

Florida Scrub Jay

This subspecies is mostly restricted to scattered, isolated patches of scrub oak in peninsular Florida. The Florida scrub jay resides permanently in oak scrub consisting of live oak, myrtle oak, Chapman oak, saw palmetto, sand palmetto, sand pine, and rosemary. It avoids wet habitats and has one of the narrowest habitat tolerances of any Florida bird. It is not expected to occur on the Big Bend site.

Reddish Egret

This species nests in the winter mostly in Florida Bay and around the Florida Keys. It has expanded its breeding range northward in recent years along the gulf coast. In 1974, an estimated five pairs nested in Tampa Bay. About 300 birds exist in Florida. This coastal species nests on mangrove islands and feeds in surrounding shallows. It is rarely seen in inland freshwater habitats. It usually nests in red mangroves up to 10 feet above the water. No reddish egrets are known to nest on the Big Bend site, but visitors are expected.

Roseate Spoonbill

Most spoonbills in Florida nest in the winter in the Florida Keys, with about 800 pairs nesting regularly. In 1974, the Florida Bay population was estimated at 2,000 to 2,500 individuals. From 10 to 15 pairs nested on Alafia Banks in Tampa Bay, near the Big Bend site, in 1977. Young birds wander north in the summer and could occur almost anywhere in the state. Several hundred individuals reside in Tampa Bay in the summer. This coastal bird usually nests on islands in thickets of large red or black mangroves. The loss of feeding and nesting areas is detrimental. This species probably occurs on the Big Bend site, but not as a breeder.

Little Blue Heron

In Florida, this species breeds from the panhandle to the Keys. The largest breeding colonies are along the coast or on adjacent islands. Little blue herons occur in shallow freshwater, brackish water, and saltwater habitats. They will nest in cypress, willow, red maple, buttonbush, red and black mangrove, cabbage palm, and Brazilian pepper. Preservation of wetlands is essential to prevent further population decline. About 250 breeding pairs were reported at Alafia Banks in Hillsborough County in 1977. This species is expected on the Big Bend site, but probably not as a breeder.

Snowy Egret

The snowy egret nests mainly in estuarine habitats in inland and coastal areas of peninsular Florida, but it is rare in western Florida. It is distributed in freshwater and coastal wetlands, but prefers saltwater. It will nest, usually on islands, in mangroves (the preferred nesting site), willow, buttonbush, wax myrtle, and other woody scrubs. In the early 1970s, about 600 pairs were believed to nest in Tampa Bay near the Alafia River in Hillsborough County. The Hillsborough County population was estimated at 512 pairs in 1976. It is likely to occur on the site, but probably not as a breeder.

Louisiana Heron

This species nests throughout Florida, mostly in estuarine colonies along the peninsula and less often in freshwater. It nests on islands or in woody vegetation over water. Nests can be in willow, buttonbush, marsh elder, wax myrtle, pond apple, or similar woody plants. Colony size has been greatly reduced since the 1930s. About 400 pairs nested at Alafia, in Tampa Bay, in 1976. It is expected on the site, but breeding there is unlikely.

Limpkin

This species occurs over most of peninsular Florida. It is usually found in slow-moving, freshwater rivers and streams, and on marshes and lake shores, usually in dense vegetation. It nests on vegetation over water. Its primary food is the apple snail. It could occur in or near mangrove swamps on the Big Bend site.

Florida Burrowing Owl

This subspecies breeds locally in south-central, northeastern, and southeastern Florida, and the Florida Keys, although its primary breeding range is central Florida. It also wanders as far as Alabama and Cuba. It nests and feeds on high, sandy ground with little vegetation, particularly prairie, sandhill, and pasture areas. It is adapted to living near human disturbance such as airports and golf courses and is also attracted to fill sites and along highway areas. Its range in Florida is being reduced because of habitat destruction. It has not been reported near the Big Bend site as a breeder.

Marian's Marsh Wren

This wren is fairly common along the gulf coast of Florida from Tarpon Springs north to Apalachicola. Although once occurring in Tampa Bay, its occurrence in Hillsborough County at the present time is questionable. Its preferred habitat is saltwater or brackish marshes, with extensive areas of black rush and cordgrass, and usually within estuaries of rivers. Dredging and filling of tidal marshes is detrimental to this species.

An additional 22 species are given special status by the FCREPA (Table 2-63.)

The FCREPA lists the osprey and Rothschild's magnificent frigatebird as threatened. The osprey currently nests at Cockroach Bay, in Tampa Bay, and in the lower Hillsborough Flood Detention Area, but it is less common on the west coast than in the rest of the state. Although the frigatebird is entirely marine, it occurs in Tampa Bay only as a migrant or visitor. Several thousand individuals could occur in summer, typically roosting in mangrove thickets.

Four land birds are considered rare (i.e., white-tailed kite, short-tailed hawk, mangrove cuckoo, black-whiskered vireo). The cuckoo and vireo nest mostly in mangrove swamps (in areas outside southern Florida), and only the vireo is expected to nest in Tampa Bay. White-tailed kites are very rare in Florida and are not expected to nest in Hillsborough County. The short-tailed hawk could occur in the Tampa Bay area in summer, but nesting is usually restricted to areas with tall deciduous trees.

All other species discussed in this section are considered species of special concern by the FCREPA, and 13 of 16 species are water birds. Only 4 of these are not expected to breed in the vicinity of the Big Bend site (i.e., great white heron, American avocet, sandwich tern, piping plover). These species would be more common in the area in the winter. The nine remaining species of water birds breed in the area. These birds are restricted to wetland vegetation (e.g., mangroves, marshes, beaches, and similar habitats) for nesting and feeding.

The three land birds of special concern (i.e., Cooper's hawk, hairy woodpecker, prairie warbler) could possibly breed in Hillsborough County in suitable habitats. The Cooper's hawk would nest along river bottoms, the hairy woodpecker in a variety of coniferous or deciduous stands, and the prairie warbler in mangrove thickets.

2.8.4.2.3.2 Summary

Forty-two species of birds with special status (Florida Game and Fresh Water Fish Commission 1979; Kale 1978) could occur on or near the Big Bend site (Table 2-63). Of these, only four species have Federal status and none of these is expected to breed on the site. The peregrine falcon could occur in the region as a very rare transient or winter resident, but onsite occurrence is doubtful. The brown pelican nests in Tampa Bay and could be a fairly regular visitor to the Big Bend site. Bald eagles may be rare visitors to the site, and red-cockaded woodpeckers are not expected because of habitat restrictions.

Twenty of the 42 special-status species are listed by the FGFWFC, including the four previously mentioned species. The peregrine falcon is considered endangered by the FGFWFC, but the state considers the red-cockaded woodpecker, bald eagle, and brown pelican to be only threatened in Florida. The wood stork and Cuban snowy plover are the only other species listed by the FGFWFC as endangered. Only the wood stork is expected on the site, but not as a breeder. Five other species or subspecies are considered threatened by the FGFWFC. Of those, only the least tern is expected on the Big Bend site. Nine other species are considered species of special concern by the FGFWFC. Seven are wading birds and all of these are expected on the site, but not as breeders. The other two species (i.e., Florida burrowing owl and Marian's marsh wren) are not expected on the site.

The FCREPA lists 42 special-status species in Hillsborough County. Four species are considered endangered, 10 are threatened, 6 are rare, and 22 are considered species of special concern (Table 2-63). Twenty of these 42 species are not on Federal or state lists. Four species are considered rare, with the black-whiskered vireo having the greatest chance of occurring on the site. The other 16 species are classified as species of special concern. Most of these species could occur on the site, although breeding is considered unlikely.

Although 42 special-status species could occur on the Big Bend site, fewer than 6 have any chance of breeding there. Of these, the species most likely to breed are the American oystercatcher and the least tern. Both species, especially the least tern, are adapted to human disturbance in the region. Both species nest on dredge-and-fill spoil areas, and least terns nest on flat rooftops of large buildings.

Twenty-six of the 42 species are associated with wetland habitats (e.g., marshes, estuaries, and beaches). Many species can be found in or near mangrove swamps or along beaches. Many of the wading birds (e.g., herons, egrets, and ibis) nest in mangroves. Many species prefer to nest in mangroves on islands, mainly to avoid domestic predators and disturbance by man. However, mainland mangrove swamps are still very important for feeding and resting.

2.8.4.2.4 Mammals

Ten terrestrial mammals that could occur on or near the Big Bend site are given special status by the Federal Government (44 FR 12, 3,636-3,654), the FGFWFC (1979), or the FCREPA (Layne 1978; Table 2-64).

One species, the Florida panther, is listed as endangered by the Federal Government. These species are also protected by the FGFWFC and recognized by the FCREPA. The river otter and bobcat may be given Federal status in the future and are now under review. Three other species (i.e., Sherman's fox squirrel, black bear, and Florida mouse) are given special status by the FGFWFC and the FCREPA. All three species are considered threatened by each agency, with the exception of the Sherman's fox squirrel, which is listed as a species of special concern by the FGFWFC. Four species are given special status solely by the FCREPA. The big brown bat, Rafinesque's big-eared bat, and the long-tailed weasel (Florida weasel) are considered rare, and the round-tailed muskrat is a species of special concern.

2.8.4.2.4.1 Species Accounts: Distribution and Habitat Preference

Florida Panther

This Florida subspecies once occurred throughout the lower southeastern United States, but is now restricted to parts of Florida. Rumors of large cats and unverified sightings are reported from other states annually, but real evidence of the subspecies outside Florida is questionable.

In Florida, this subspecies is generally restricted to forest types that also support white-tailed deer, one of the panther's main foods. It has been reported from many different habitats, however. There were five verified reports in Florida between 1967 and 1975, but none were from Hillsborough County. However, between 1961 and 1976, 83 unverified panther sightings were reported in the region consisting of Hillsborough County and the seven counties around it. The majority of reports from this region came from the Myakka River State Park in Sarasota County. Estimates of abundance in Florida range from 30 to 300 individuals. It is unlikely that more than 30 cats now exist in Florida (Layne 1978). This subspecies could not occur on the Big Bend site as a resident, and chances of its ever occurring there, even as a wandering individual, are extremely rare in view of the disturbed nature of the area and lack of its major prey, the white-tailed deer.

River Otter

This species inhabits streams, rivers, lake borders, and sometimes saltwater habitats, and occurs over much of the undisturbed parts of the state. It is considered uncommon to rare in the Alafia and Little Manatee river basins in Hillsborough County. Its occurrence on the site is unlikely due to the lack of suitable habitat.

Bobcat

The bobcat is restricted to areas with dense vegetative cover, especially swamps and forested areas in Florida. It is not as common in regions with high human populations and man-caused disturbances. It is not expected on the Big Bend site because of a lack of sufficient undisturbed habitat.

Black Bear

The black bear occurs in Florida in scattered populations in large swamps, bays, and thickets. Larger populations occur in the Apalachicola National Forest, Osceola National Forest, and in swamps along the northeastern coast south to Seminole County. Bear prefer dense vegetative cover such as is found in middle Florida swamps. The Florida population is estimated at 500 bears (Pelton and Nichols 1973). A stable or sedentary population is not believed to exist in Hillsborough County. The black bear is considered rare in the region.

Sherman's Fox Squirrel

This subspecies occurs throughout much of peninsular Florida, including Hillsborough County. Its primary range is east of the Suwannee River and north of Lake Okeechobee. Its primary habitat is the longleaf pine-turkey oak associations of the sand hills. Because of the logging of large longleaf pines, a reduced population of squirrels now exists in pure turkey oak stands. This species has also been reported in pine flatwoods. Reduction of primary habitat is the main reason for the decline of this species. It is not expected on the Big Bend site.

Florida Mouse

The Florida mouse, which is endemic to Florida, is confined to peninsular Florida, predominantly from the west-central coast inland. It exists in a network of patchy, isolated populations, primarily in early, successional, sand pine scrub. It also occurs in longleaf pine-turkey oak, south Florida slash pine-turkey oak, pine flatwoods, and scrubby flatwoods associations. Its habitats are characterized by dry conditions, open tree stands, and clumps of scrubby oaks and other shrubs with patches of bare ground and well-drained, sandy soils. The species is not expected on the Big Bend site.

Big Brown and Rafinesque's Big-Eared Bats

Little is known of these two species in Florida. Based on limited museum specimens, it does not appear that either species is very common in the state. Both species are known to roost in old buildings and in trees in forested parts of the state. Big brown bats are known to roost in buildings in Brazilian free-tailed bat colonies. Rafinesque's big-eared bat prefers more forested areas with hammock-type vegetation. While urban or forested parts of the site would provide suitable habitat, the occurrence of these species at the site is unlikely in view of their general scarcity in the region.

Florida Weasel (Long-Tailed Weasel)

This subspecies occurs in the lower two-thirds of Florida, except for the southeast sections. It has been captured in a variety of habitats including pinelands, hardwood forests, swamps, tropical hammocks, and sand pine scrub. It is believed to be very uncommon in Florida, since only a few specimens have been taken. Its occurrence on the Big Bend site is unlikely.

Round-Tailed Muskrat

This species occurs only in Florida and in extreme southeastern Georgia. It occurs in localized populations over much of Florida in favorable freshwater and saltwater habitats. Its primary habitat is shallow emergent marshes with dense stands of maiden cane and pickerel weed. It has not been reported near the Big Bend site.

2.8.4.2.4.2 Summary

Of the 11 special-status mammal species that could occur on or near the Big Bend site, only the manatee has been verified on the site. Of the other 10 species, only the big brown bat and Rafinesque's big-eared bat would have any chance of occurring on the site, and these species are not expected because of their scarcity in the region. The other eight species are not expected because of habitat limitations.

2.8.5 WETLANDS

Wetlands have been defined as areas in which the water table is at, near, or above the land surface for a significant part of most years (Anderson et al. 1976). The distribution and areal extent of wetlands in the coastal zone of the Tampa Bay complex are presented in Figure 2-8. Approximately 6.5 percent (43,230 acres) of Hillsborough County is classified as wetlands, and most of this acreage is forested (Texas Instruments, Inc. 1978a). Types of wetland vegetation occurring in Hillsborough County are described in Section 2.2.4.2.4 of this report. The only wetlands occurring on the Big Bend site are the mangrove areas shown as Vegetation Sample A in Figure 2-21.

2.8.6 FLOOD PLAINS OR FLOOD RETENTION AREAS

The Big Bend Station is located in the coastal area of Hillsborough Bay where tidal surge caused by hurricanes and tropical storms is the main flooding threat.

The existence and severity of flood hazards in the unincorporated areas of Hillsborough County were determined in a flood insurance study (U.S. Federal Emergency Management Agency 1980). The results of this study indicate that the general area near the station is in the 100-year flood plain, which has an average 100-year flood level of 11 feet above mean sea level (msl). The average ground elevation around the station is approximately 8.5 feet above msl. The study also indicates that the station will be affected by waves of the bay during flooding periods.

Alluvial land that is covered by water from overflowing streams during much of the year occurs throughout Hillsborough County. Large areas occur along the Alafia, Little Manatee, and Hillsborough rivers. Large areas also occur along Rocky, Sweetwater, and Bullfrog creeks, and along streams in the county (U.S. Department of Agriculture 1958). These wet areas are covered by generally dense vegetation, including shrubs, vines, and hardwood, cypress, and occasional pine trees.

A minor flood plain occurs on or along the banks of Newman Branch near the southern boundary of the TECO site. No flood-control structures exist there. As part of the southern boundary itself, a canal has been dredged out in recent years. The canal serves as an access route between residential properties and a marina which are adjacent to the TECO site. The canal is probably instrumental in flood mitigation. Jackson Branch also occurs on the TECO site. It is the smallest of the waterways present, and links Vegetation Sample B (Figure 2-21) with Tampa Bay in the vicinity of the ash-settling pond discharge point. The dense vegetation in the channel cut by Jackson Branch is the only evident means of flood retention in the area.

2.8.7 SURFACE WATERS

Big Bend Station is 5 miles north of Ruskin, Hillsborough County, Florida, on the eastern shore of Hillsborough Bay, which is part of the Tampa Bay estuary. A number of hydrologically sensitive considerations associated with Hillsborough Bay, the main surface water body in the vicinity of the plant site, are described below (Florida Institute of Oceanography 1973).

2.8.7.1 Dredge-and-Fill Operations

The lagoons and estuaries of the Florida gulf coast, including the Tampa Bay estuary, are extremely fertile and productive areas for fish, shellfish, and crustaceans. Their shallow nature and their position at the boundary between the freshwater and marine environments make them extremely valuable as primary production areas. These estuarine and bay areas are being lost at a considerable rate as a result of exploitation and development. Dredging is the most serious problem.

Dredging is done for two purposes: landfill operations for shoreline development and the creation and maintenance of navigational channels and canals. The effects of dredging have been studied by several investigators. Siltation and turbidity during the dredging operation can cause considerable damage. Reduced production over a wide area during and after the dredging period has been observed. The long-term losses caused by dredging are of two types: grass beds and marine life associated with them are destroyed, and the substrate is modified. The dredged area and the area where material is placed are effectively lost as habitat; the dredged channel is generally too deep for the regrowth of marine grasses, and spoil areas are inundated.

Dredging procedures are being improved and supervision of dredging projects has become more common in recent years. It appears that some dredging, especially for navigational purposes, will continue to be necessary. Applicable regulations and guidelines established for dredging must be observed in order to prevent adverse effects on the water environment from dredge-and-fill operations.

2.8.7.2 Industrial Pollution and Sewage Contamination

Water pollution generally is associated with the large communities and concentrations of industry. Domestic waste pollution is greatest in Tampa Bay and vicinity. Hillsborough Bay has been listed as one of the 10 estuarine areas strongly affected by water pollution along the west Florida coast.

McNulty, Lindall, and Sykes (1972) have developed an inventory of natural and man-made features of estuaries on the west coast of Florida. The inventory includes a classification of major or minor sources of industrial waste and major or minor sources of domestic waste. Major sources of industrial waste are those with an effluent strength exceeding 8,000 population equivalents, while sources of major domestic waste are those with a flow in excess of 4 million gallons per day. Also included are tabular data on source of waste, receiving waters, average daily discharge, treatment, estimated average 5-day biological oxygen demand of discharge, and estimated population equivalence of discharge. For sources of industrial waste, the tables list the principal products and the type of waste produced.

2.8.7.3 Thermal Discharge

Waste heat carried by cooling waters is another form of effluent generated by power plants and industrial installations. With the continually expanding population of the Florida west coast areas, and the need to provide power and jobs for this increased population, thermal discharges could present a threat to environmental quality. To prevent environmental damage from heated waters, the Florida Department of Environmental Regulation (FDER) has developed standards for thermal discharges. In the coastal areas near Hillsborough Bay, the temperature at the point of discharge must not be more than 2°F higher than the ambient temperature and must not exceed 92°F during June, July, August, and September. During the remainder of the year, the temperature must not be more than 4°F higher than the ambient temperature and must not exceed 90°F. Upon application, and on a case-by-case basis, the FDER may establish a zone of mixing beyond the point of discharge to afford a reasonable opportunity for dilution and mixture of heated water discharges with the receiving water body. Zones of mixing for thermal discharges from nonrecirculated cooling water systems of new sources will be allowed if supported by a demonstration by an applicant that the proposed mixing zone will assure the protection and propogation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made.

Careful examination of the receiving waters potentially affected by a thermal discharge should be undertaken before and during discharge to ascertain that permanent damage will not take place.

2.8.7.4 Beach Erosion

Beach erosion is generally correlated with development in coastal areas. Man's interference with natural shore processes is the major cause of the increased erosion in highly populated areas.

Groins, which have serious leeside erosion problems, have been installed in many areas along the Florida west coast shoreline, and have caused considerably more harm than good. Seawalls have, in many cases, protected valuable property or dune faces, but when built as vertical bulkheads, they have often caused lowering and increased erosion of the beach itself. A close examination of the erosion situation reveals that the main source of erosion problems is the improved inlet. Erosion in the nearshore areas of the gulf beaches on the west coast of Florida has been estimated at approximately 9 million cubic yards per year. More than one-third of this erosion has been attributed to the improved inlets (U.S. Army Corps of Engineers 1971).

2.8.8 GROUND-WATER RECHARGE

The hydrologic system of the west-central Florida area generally includes three ground-water units: (1) the upper unconfined water-table aquifer; (2) shallow artesian aquifer; and (3) the lower, generally artesian Floridan aquifer (Parker 1951). Ground water and surface water are hydraulically interconnected, and streamflows in the region are chiefly maintained by ground-water discharge during the dry season and to a large extent by greatly increased base flow during wet seasons. In the Tri-County area (Hillsborough, Pasco, and Pinellas), rainfall now provides an average input into the hydrologic system of about 49 inches yearly, although prior to 1961 the normal precipitation was about 55 inches annually (Parker 1975). Essentially all of the rainfall is lost to evaporation, surface withdrawal, and direct runoff to the sea. The normal recharge of the water-table aquifer is vertical from local surface water. The recharge of the shallow artesian aquifer is upward leakage from the Floridan aquifer near Big Bend Station. The major recharge area of the Floridan aquifer is the exposed Ocala uplife where the upper confining beds are absent. Rainfall that infiltrates the water-table aquifer generally flows in a westerly direction to natural discharge areas such as streams, lakes, marshes, and the Gulf of Mexico and its bays and estuaries. Fresh ground water in the Floridan aquifer also moves in a westerly direction toward natural discharge areas in the lower reaches of streams or directly into the Gulf of Mexico. Springs in and adjacent to the Tri-County area discharge more than 400 million gallons per day (mgd) of ground water to the sea. Typical recharge zones include sinkholes, abandoned phosphate-mining pits, and areas along streams where the potentiometric surface is below the stream-water level (Dove and Schreuder 1979).

It has been asserted that Florida's water supplies are probably the most abundant in the Western Hemisphere (Florida Conservation Foundation, Inc. 1977). Nevertheless, problems of supplying needed quantities of fresh water are common, particularly in the coastal zones where most of the population lies and greatest demands occur (Parker 1973, 1975). Water resource development for man's use, especially for drinking purposes, has been small in comparison with natural system losses. In 1975, municipal water usage within the boundaries of the Southwest Florida Water Management District (SWFWMD) was estimated to be 218 mgd (Geraghty and Miller, Inc. 1977). Most of this total (about 151 mgd) was used in the Tri-County area (99 mgd from ground water and 53 mgd from surface water). Within the SWFWMD approximately 790 mgd of ground water was withdrawn for agricultural usage and 454 mgd for industrial operations. Consumptive use was estimated to be 162 mgd, or roughly 45 percent of the total water withdrawal in the Tri-County area for 1975 (Dove and Schreuder 1979).

There are both man-made and natural constraints upon the degree of ground-water development that can be implemented at any particular location. These constraints are often translated into a definition of "safe yield," or that quantity of water that can be removed from an aquifer without adverse impact on the ground-water system. The definition process, however, is not a simple one; it involves not only the collection and analysis of evidence of adverse environmental impact, but also the establishment of threshold levels of impact acceptability. Determination of acceptable impact levels is in fact the fundamental problem in assessment of the effects of human endeavors on the environment or on the quality of human life (Dove and Schreuder 1979).

Lowered water levels not only affect water quality; they also reduce stream flow and lake stages and significantly impact aquatic vegetation, wildlife, and recreation. Property values, land use, and socioeconomic and political conditions are also affected. For example, coastal-zone well fields developed for Tampa and St. Petersburg were lost to saltwater encroachment in the 1920s (Parker 1973), and recently saltwater encroachment ruined New Port Richey's well field as well as hundreds of privately-owned wells in western Pasco and northwestern Hillsborough County in the Upper Tampa Bay area. Ground-water withdrawal at the Eldridge-Wilde Well Field lowered lake levels 2.4 miles away and caused other changes in the surrounding ecosystem (Black, Crow and Eidsness, Inc. 1974). Similar problems also developed in and around all the big well fields in the Upper Tampa Bay area; many shallow wells went dry, numerous sinkholes developed, many lakes lost most of their water area, and regional "water wars" developed between St. Petersburg and Pinellas County on one hand and the inland areas on the other.

Under natural conditions, the quality of ground water varies only slightly. However, in some locations, particularly in recharge areas, contaminated water from drainage may percolate into an aquifer under natural conditions or through wells used to dispose of surface water or to recharge the aquifer. Withdrawal of water from the aquifer may cause water of poor chemical quality (e.g., saltwater) to be drawn into the coastal aquifer system, including the heavily pumped areas of the phosphate mining and processing region.

Potential major ground-water contamination sources at a coal-fired powerplant include the coal storage areas, the sludge pond, and the landfill site. The poor quality surface runoff and leachates generated at these locations may seep into the underlying aquifer.

2.8.9 RECREATION AREAS

2.8.9.1 Existing Areas

There is an abundance of public and private recreational areas in the six-county study area. Local facilities, such as county playgrounds, neighborhood parks, and county parks, account for the majority of recreational areas found in each county. The remaining local facilities consist of boat ramps, community centers, public beaches, and bike trails. Of the six counties, Hardee has the smallest number of public recreational facilities, and most of these are concentrated in Wachula. The majority of recreational areas in Pinellas and Manatee Counties are public beaches along the coast. Polk County facilities, including 15 public boat ramps, are concentrated in the urban areas, primarily in the central portion of the county. There is also a bicycle trail in Lakeland. Hillsborough County also has a bicycle trail, and, as a whole, possesses a wide variety of recreational opportunities, particularly around Tampa. Recreational areas in Pasco County are limited, and they are clustered mainly around Dade City and the Port Richie-New Port Richie area (Figure 2-20; Florida State Department of Transportation, undated-a,b,c,d,e,f,g,h).

Private recreational facilities also serve the region's population. These facilities include golf courses, tennis courts, marinas, and campgrounds.

In addition to private recreational areas, the State of Florida maintains one museum, one historic area, one archaeological site, and nine parks and recreation areas for the residents of the six-county region. The State also provides the region with six canoe trails, only Pinellas County lacks such a trail (Florida State Department of Transportation, undated-a,b,c,d,e,f,g,h).

There are four national wildlife refuges and preserves in the region: the Pinellas National Wildlife Refuge, the Egmont Key National Wildlife Refuge in Hillsborough County, the Passage Key National Wildlife Refuge in Manatee County, and the Anclote National Wildlife Preserve in Pasco County. The state also manages wildlife preserves. The largest of these is the 53,600-acre Avon Park Wildlife Management Area in Polk County. The remaining preserves include the the Cockroach Bay Aquatic Preserve; Green Swamp Wildlife Management Area; the Pinellas County Aquatic Preserve; the Boca Ciega Bay Aquatic Preserve and the Caladesi Island Aquatic Preserve--both in Pinellas County; Pasco County's Robert Crown State Wilderness Area, the Richloam Wildlife Management area, and the Weedon Island State Preserve and Hammock State Feature--both located in Pinellas County (Florida State Department of Transportation, undated-a,b,c,d,e,f,g,h).

2.8.9.2 Future Areas

Projections of future recreational needs indicate a deficiency in the number of community and neighborhood parks. This shortage is made more acute by the region's projected rapid population increase (Tampa Bay Regional Planning Council 1977). In some counties, such as Hillsborough, there is a current shortage of such parks, and the gap between the actual and the desired number of parks is expected to widen (Hillsborough County Board of County Commissioners 1978; Tampa Bay Regional Planning Council 1977). In order to meet the increased demand for recreational facilities, district park acreage in much of the study area will also have to be increased. Hillsborough, Pasco, and Pinellas Counties, for example, may require at least an additional 500 acres of district parkland by the year 2000 to satisfy the potential demand (Tampa Bay Regional Planning Council 1977). The region currently has enough regional parkland to satisfy its population. The anticipated population increases, however, may overtax the facilities unless future sites are acquired and developed. In addition, many of these parks are undeveloped, and major expenditures will be required for development and operation. Of all the counties, Pinellas has the greatest need for regional parkland because the County's intense development has lessened the availability of land for recreational uses (Tampa Bay Regional Planning Council 1977).

2.8.10 ARCHAEOLOGICAL AND HISTORIC SITES

There are over 1,000 historic sites and 700 archaeological sites in the six-county study area (U.S. Department of the Interior 1979; Florida Bureau of Historic Sites and Properties, undated). Sixty-nine percent of the historic sites are located in Pinellas County and 21 percent are in Hillsborough County. The majority of these sites are historic buildings situated in Tampa and St. Petersburg. Of the total number of archaeological sites, 47 percent are located in Hillsborough County and 20 percent are found in Pinellas County. These sites are primarily classified as lithic scatter sites and mounds (Florida Bureau of Historic Sites and Properties, undated). Tables 2-65 through 2-67 show the number and type of historic and archaeological sites situated in each of the six counties. The National Register sites are shown on Figure 2-20.

Table 2-58. Land use on Hillsborough County farms for 1969 and 1974[a]

Land use category	Year 1969 (acres)	 1974 (acres)
Total cropland	117,712	110,945
Harvested cropland	68,204	58,274
Cropland used only for pasture or grazing	39,614	46,511
Other cropland	9,894	6,160
Total woodland	101,777	63,672
Other land	155,278	183,561
Irrigated land	29,762	26,359
Total land in farms[b]	374,767	358,178
Approximate land area in Hillsborough County	664,192	664,192
Proportion of land in farms	56.4%	53.9%

[a] Adapted from U.S. Department of Commerce (1974).
[b] Sum of total cropland, total woodland, and other land.

Table 2-59. Aquatic invertebrates of special status that have been reported from the Tampa Bay area

Common name	Scientific name	Status Federal	 FGFWFC	 FCREPA
Mangrove crab	*Aratus pisonii*	--	--	T
Atlantic geoduck	*Panopea bitruncata*	--	--	R

Abbreviations:
Federal = 44 FR 12, 3,636-3,654.
FGFWFC = Florida Game and Fresh Water Fish Commission (1979).
FCREPA = Florida Committee on Rare and Endangered Plants and Animals (1976).
T = threatened.
R = rare.

Table 2-60. Fishes of special status that have been reported from the Tampa Bay area

Common name	Scientific name	Status		
		Federal	FGFWFC	FCREPA
Atlantic sturgeon	*Acipenser oxyrhynchus*	--	SSC	T
Rivulus	*Rivulus marmoratus*	--	SSC	T
Opossum pipefish	*Oostethus lineatus*	--	--	R
Mountain mullet	*Agonostomus monticola*	--	--	R

Abbreviations:
Federal = 44 FR 12, 3,636-3,654.
FGFWFC = Florida Game and Fresh Water Fish Commission (1979).
FCREPA = Florida Committee on Rare and Endangered Plants and Animals (1976).
T = threatened.
R = rare.
SSC = species of special concern.

Table 2-61. Terrestrial invertebrates of special status that occur in Florida

Common name	Scientific name	Status Federal[a]	FGFWFC[b]	FCREPA[c]
Stock island tree snail[d]	*Orthalicus reses*	T	T	
Bahama swallowtail butterfly[d]	*Papilio andraemon bonhotei*	T	T	
Schaus swallowtail butterfly[d]	*Papilio aristodemus ponceanus*	T	T	
Florida tree snail[d]	*Liguus fasciatus*	UR		
Atala butterfly[e]	*Eumaeus atala florida*	UR		
Gopher tortoise copris beetle[f]	*Copris gopheri*			T
Peninsular gopher tortoise dung beetle[f]	*Onthophagus polyphemi polyphemi*			T
Gopher tortoise aphodium beetle[f]	*Aphodius troglodytes*			T
Southwest Florida wingless burrowing beetle	*Mycotrupes pedester*			T
Abott's purse-web spider	*Atypus abotti*			SSC
Scarab beetle	*Copris howdeni*			SU
Scarab beetle	*Aphodius aegrotus*			SU
Scarab beetle	*Peltotrupes profundus*			SU

Abbreviations:

FGFWFC = Florida Game and Fresh Water Fish Commission.
FCREPA = Florida Committee on Rare and Endangered Plants and Animals.
T = threatened.
UR = under review.
SSC = species of special concern.
SU = status undetermined.

[a] From 45 FR 99, 33,768-33,781.

[b] From Florida Game and Fresh Water Fish Commission (1979).

[c] From Layne et al. (1977).

[d] Occur primarily in southern Florida, southeastern Florida, and the Florida Keys.

[e] Distribution unknown.

[f] Live only in gopher tortoise burrows.

Table 2-62. Amphibians and reptiles of special status that could occur on or near the Big Bend site

Common name	Scientific name	Status		
		Federal[a]	FGFWFC[b]	FCREPA[c]
Florida crawfish frog	*Rana areolata aesopus*		SSC	T
River cooter[d]	*Chrysemys concinna*	UR	SSC	T
Gopher tortoise	*Gopherus polyphemus*		SSC	T
American alligator	*Alligator mississippiensis*	T	SSC	SSC
Eastern indigo snake	*Drymarchon corais couperi*	T	T	SSC
Short-tailed snake	*Stilosoma extenuatum*	UR	T	E
Atlantic loggerhead	*Caretta caretta caretta*	T	T	T
Atlantic green turtle	*Chelonia mydas mydas*	E	E	E
Atlantic leatherback	*Dermochelys coriacea coriacea*	E	E	R
Atlantic ridley	*Lepidochelys kempi*	E	E	E

Abbreviations:
FGFWFC = Florida Game and Fresh Water Fish Commission.
FCREPA = Florida Committee on Rare and Endangered Plants and Animals.
R = rare.
E = endangered.
T = threatened.
UR = under review.
SSC = species of special concern.

[a] From 44 FR 12, 3,636-3,654.

[b] From Florida Game and Fresh Water Fish Commission (1979).

[c] From McDiarmid (1978).

[d] The subspecies Suwannee cooter (*Chrysemys concinna suwanniensis*) has special status in Florida and has been reported in the Alafia River in Hillsborough County.

Table 2-63. Birds of special status whose ranges include the Big Bend site (Sheet 1 of 2)

Common name	Scientific name	Status		
		Federal[b]	FGFWFC[c]	FCREPA[d]
Wood stork	Mycteria americana		E	E
Peregrine falcon	Falco peregrinus	E	E	E
Cuban snowy plover[a]	Charadrius alexandrinus tenuirostris		E	E
Red-cockaded woodpecker	Picoides borealis	E	T	E
Eastern brown pelican[a]	Pelecanus occidentalis carolinensis	E	T	T
Rothschild's magnificent frigatebird[a]	Fregata magnificens rothschildi			T
Southern bald eagle[a]	Haliaeetus leucocephalus leucocephalus	E	T	T
Osprey	Pandion haliaetus			T
Southeastern American kestrel[a]	Falco sparverius paulus		T	T
Audubon's caracara[a]	Caracara cheriway auduboni		T	T
Florida sandhill crane[a]	Grus canadensis pratensis		T	T
American oystercatcher	Haematopus palliatus		SSC	T
Least tern	Sterna albifrons		T	T
Florida scrub jay[a]	Aphelocoma coerulescens coerulescens		T	T
Reddish egret	Dichromanassa rufescens		SSC	R
Roseate spoonbill	Ajaia ajaia		SSC	R
White-tailed kite	Elanus leucurus			R
Short-tailed hawk	Buteo brachyurus			R
Mangrove cuckoo	Coccyzus minor			R
Black-whiskered vireo	Vireo altiloquus			R
Florida great white heron[a]	Ardea herodius occidentalis			SSC
Little blue heron	Florida caerulea		SSC	SSC
Great egret	Casmerodius albus			SSC
Snowy egret	Egretta thula		SSC	SSC
Louisiana heron	Hydranassa tricolor		SSC	SSC
Black-crowned night heron	Nycticorax nycticorax			SSC
Yellow-crowned night heron	Nytanassa violacea			SSC
Eastern least bittern[a]	Ixobrychus exilis exilis			SSC
Glossy ibis	Plegadis falcinellus			SSC
White ibis	Eudocimus albus			SSC

Note: See abbreviations and footnotes at end of table.

Table 2-63. Birds of special status whose ranges include the Big Bend site (Sheet 2 of 2)

Common name	Scientific name	Status		
		Federal[b]	FGFWFC[c]	FCREPA[d]
Cooper's hawk	*Accipiter cooperii*			SSC
Limpkin	*Aramus guarauna*		SSC	SSC
Piping plover	*Charadrius melodus*			SSC
American avocet	*Recurvirostra americana*			SSC
Royal tern	*Sterna maxima*			SSC
Sandwich tern	*Sterna sandvicensis*			SSC
Caspian tern	*Sterna caspia*			SSC
Black skimmer	*Rynchops niger*			SSC
Florida burrowing owl[a]	*Athene cunicularia floridana*		SSC	SSC
Southern hairy woodpecker[a]	*Picoides villosus auduboni*			SSC
Marian's marsh wren[a]	*Cistothorus palustris marianae*		SSC	SSC
Florida prairie warbler[a]	*Dendroica discolor paludicola*			SSC
Total species 42				

Abbreviations:

FGFWFC = Florida Game and Fresh Water Fish Commission.
FCREPA = Florida Committee on Rare and Endangered Plants and Animals.
SSC = species of special concern.
E = endangered.
T = threatened.
R = rare.

[a] Indicates subspecies.
[b] From 44 FR 12, 3,636-3,654.
[c] From Florida Game and Fresh Water Fish Commission (1979).
[d] From Kale (1978).

Table 2-64. Mammals of special status that could occur on or near the Big Bend site

Common name	Scientific name	Status		
		Federal[a]	FGFWFC[b]	FCREPA[c]
Big brown bat	*Eptesicus fuscus*			R
Rafinesque's big-eared bat	*Plecotus refinesquii*			R
Fox squirrel[d]	*Sciurus niger*		SSC	T
Florida mouse	*Peromyscus floridanus*		T	T
Black bear	*Ursus americanus*		T	T
Long-tailed weasel[e]	*Mustela frenata*			R
River otter	*Lutra canadensis*	UR		
Mountain lion[f]	*Felis concolor*	E	E	E
Bobcat	*Felis rufus*	UR		
Manatee	*Trichechus manatus*	E	E	T
Round-tailed muskrat	*Neofiber alleni*			SSC

Abbreviations:
FGFWFC = Florida Game and Fresh Water Fish Commission.
FCREPA = Florida Committee on Rare and Endangered Plants and Animals.
R = rare.
E = endangered.
T = threatened.
UR = under review.
SSC = species of special concern.

[a] From 44 FR 12, 3,636-3,654.

[b] From Florida Game and Fresh Water Fish Commission (1979).

[c] From Layne (1978).

[d] The subspecies, Sherman's fox squirrel (*Sciurus niger shermani*), could occur on or near the Big Bend site.

[e] The subspecies, Florida weasel (*Mustela frenata peninsular*), could occur on or near the Big Bend site.

[f] The subspecies, Florida panther (*Felis concolor coryi*), could occur in the region.

Table 2-65. Number and type of historic sites by county[a]

Type of site	County					
	Hardee	Hillsborough	Manatee	Pasco	Pinellas	Polk
Airport	--	--	--	--	1	--
Battlefield site	--	--	--	--	--	1
Building	--	184	--	--	618	60
Building site	--	2	6	--	--	--
Cemetery	--	--	--	--	6	--
Church	1	11	--	1	13	2
Community	--	--	--	--	--	1
Country club	--	--	--	--	1	--
Destroyed	--	1	--	--	--	--
Estate/manor	--	--	--	--	3	--
Fort	1	1	--	2	2	1
Fort site	--	1	--	--	1	--
Garden	--	1	--	--	1	--
Historic district	--	1	--	--	4	--
Historic refuge	--	1	3	--	1	1
Homestead	--	--	5	--	2	--
Indian town and fields	--	--	--	--	--	1
Insufficient information	--	2	--	--	9	2
Lake sanctuary	--	--	1	--	--	--
Mill	--	--	--	1	--	--
Object	--	1	--	--	4	--
Park	--	1	--	--	3	--
Pier	--	--	--	--	1	--
Sawmill	1	--	--	--	--	--
Site	--	3	--	--	13	--
Structure	--	4	--	--	8	1
Undetermined status	2	--	--	--	--	--
Well	--	--	--	--	2	--
Total	5	215	15	4	693	70

[a] From Florida Bureau of Historic Sites and Properties (undated) and U.S. Department of the Interior (1979).

Table 2-66. Number of *National Register* historic sites by county [a,b]

County	Number
Hardee	1
Hillsborough	23
Manatee	4
Pasco	0
Pinellas	10
Polk	6

[a] From U.S. Department of the Interior (1979).

[b] These sites are included in the totals in Table 2-65.

Table 2-67. Number and type of archaeological sites by county[a] (Sheet 1 of 2)

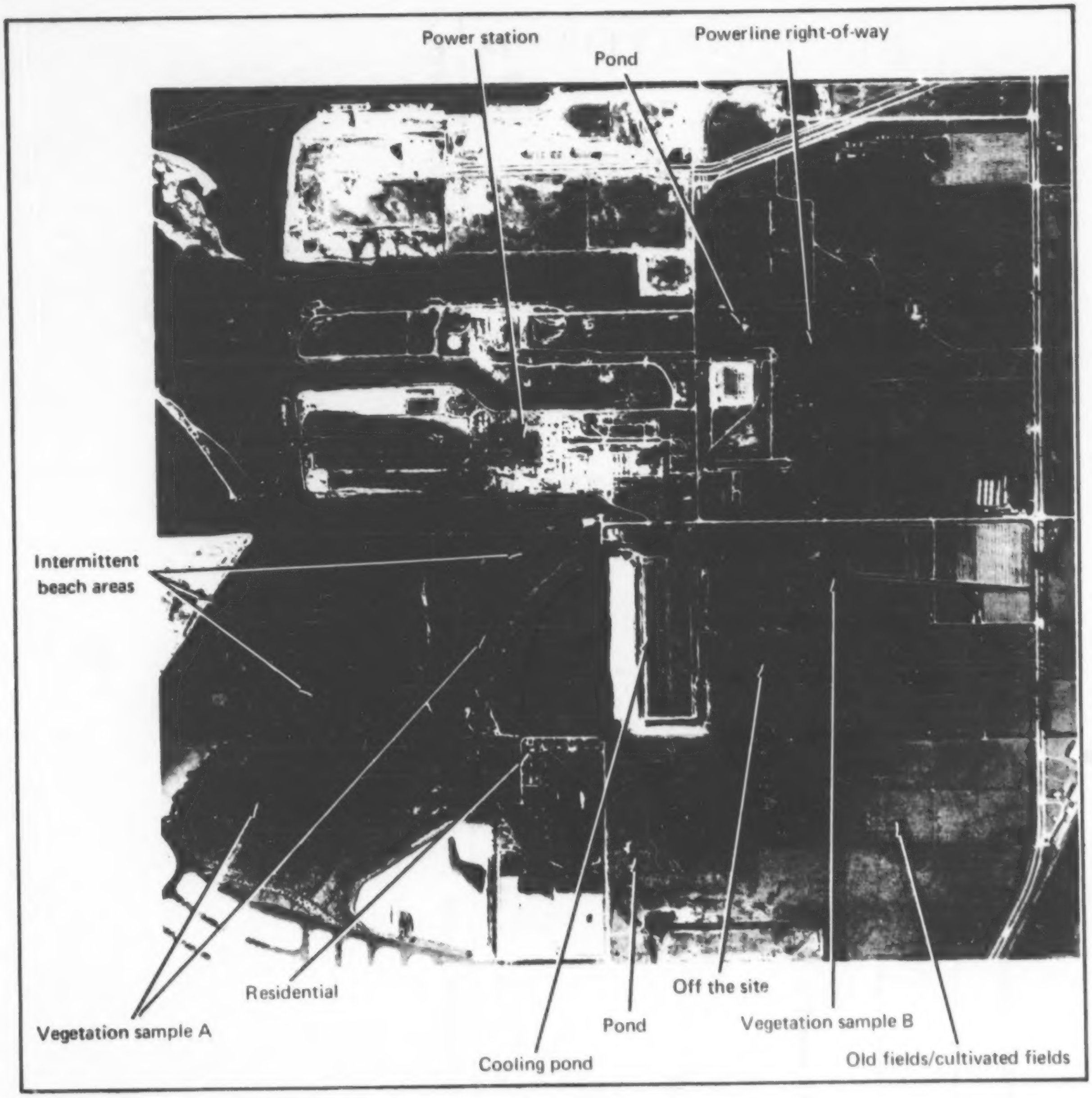
Type of site	County					
	Hardee	Hillsborough	Manatee	Pasco	Pinellas	Polk
Archaeological district	--	1	--	--	--	1
Artifact	--	--	--	2	--	--
Artifact scatter	--	--	--	--	1	3
Burial mound	1	8	27	3	7	--
Burial and temple mound	--	--	1	1	1	--
Campsite	3	--	1	--	--	--
Cemetery	1	2	4	--	--	--
Ceremonial mound	--	--	1	--	--	--
Undetermined status	9	--	--	--	--	--
Earthworks	--	--	1	--	--	--
Find location	1	--	--	--	--	--
Flint and shard scatter	1	--	--	--	--	--
Flint scatter	7	--	--	--	--	--
Flint quarry	--	4	--	--	--	--
Fort	--	1	--	--	1	--
Fossil shells	--	--	--	--	--	--
Habitation	1	--	3	--	11	4
Insufficient information	5	16	1	8	44	11
Lithic scatter	--	196	19	21	--	--
Lithic and shell scatter	--	--	1	--	12	2
Midden	--	7	4	--	1	--
Midden and mound	--	--	1	--	1	--
Midden and burial mound	--	--	1	--	--	--
Midden mound	--	--	1	--	--	1
Mission	--	--	--	--	19	3
Mound(s)	7	46	28	6	--	--
Mound and shell midden	--	1	1	--	3	--
Mound complex	--	--	--	--	--	--
Sand and shell ridge	--	--	1	--	--	--
Shell and black dirt midden	--	--	2	--	--	--
Shell and burial mound	--	--	1	--	--	--

Note: See footnote at end of table.

Table 2-67. Number and type of archaeological sites by county[a] (Sheet 2 of 2)

Type of site	County					
	Hardee	Hillsborough	Manatee	Pasco	Pinellas	Polk
Shell deposit	—	—	1	—	—	—
Shell midden	—	28	10	2	27	1
Shell midden and burial mound	—	—	1	—	—	—
Shell mound	—	—	1	—	—	—
Shell ridge	—	—	6	—	—	—
Shard area	—	—	1	—	—	—
Shard and flint area	—	0	—	—	—	—
Shard and lithic scatter	—	17	—	7	8	—
Shard scatter	—	1	—	—	—	—
Site	—	1	—	—	—	—
Temple mound	—	1	2	1	4	—
Village	—	3	3	—	—	—
Village and mound	—	—	1	—	—	—
Total archaeological sites	36	334	125	51	140	30

[a] From Florida Bureau of Historic Sites and Properties (undated) and U.S. Department of the Interior (1979).


Power station
Pond
Powerline right-of-way
Intermittent beach areas
Residential
Vegetation sample A
Cooling pond
Pond
Off the site
Vegetation sample B
Old fields/cultivated fields

Source: Wunderlin et al. (1975).

500 1000 Feet

Figure 2-21. Aerial view of the TECO Big Bend 4 site showing vegetation cover types.

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Chapter 3

ALTERNATIVES

3.1 MANAGEMENT ALTERNATIVES

Technical approaches to meeting the anticipated need for power by means other than construction of the proposed facility are the subject of the following sections. The alternatives to be considered are no action, purchase of power, uprating older units, reactivation of retired facilities, joint projects with adjacent utilities, and construction of a smaller facility.

3.1.1 NO ACTION

As discussed in Section 1.4, delay of Big Bend Unit 4 for one year would reduce the firm winter reserve load to 9 percent in 1985-1986 through 1987-1988, and to 3 percent by 1989-1990. Should TECO experience a capacity deficiency, it would implement a plan of priority assignments to reduce the load and ensure system stability. This is a short-term plan, however, and cannot be relied upon in lieu of long-term system planning. The plan, beginning with curtailment of the interruptible load, has frequently been implemented in varying degrees. The latter phases of the plan, involving curtailment of firm load, have been required only on very rare occasions, as on January 18, 1977, when it snowed in Tampa.

3.1.2 PURCHASE OF POWER

The purchase of power--assuming it were available--from other Florida utilities would be the same as the no action alternative, considering its potential effect on Florida energy availability. Purchase of power from outside Florida (if adequate transmission facilities existed) would provide a temporary solution to the need for power by the State, but it would result in a concurrent reduction in reserves for the supplying utility. While power purchase can be a short-term solution, it is becoming more difficult to obtain the necessary approval for the construction of additional capacity for long-term sales to other utilities. TECO has not actively pursued long-term power purchases outside Florida because of questions relating to the transmission line/intertie capability to sustain long-term loads. A firm capacity purchase power contract is being negotiated to replace the combustion turbines that were being considered for operation in 1983 and 1984. The contract calls for the purchase of power from a new coal unit, which purchase would have the effect of meeting predicted load growth and reducing the need for more expensive oil-generated power in the TECO system. Adequate emergency power is normally available for short periods for purposes of reliability, through ties with Florida Power Corporation, Florida Power and Light Company, and the City of Lakeland.

In addition, TECO participates in economy interchange transactions on an hourly basis to reduce the total system operation expense (Tampa Electric Company 1980).

3.1.3 UPRATING OF OLDER UNITS

While the uprating of older units can be a solution to a utility's capacity needs, this is generally true only for larger utilities where the needed increase in capacity is only a small fraction of the entire system's capability. This is not the case for

TECO. About 15 percent in additional capacity is required in the mid-1980s, and there is no way that the existing units could be rerated to achieve this additional capacity. An alternative to uprating existing units is to defer planned derating of existing units. In the time span of concern, TECO will not be derating any units that could be retained on line. In fact, the total derating occurring among other Florida utilities in the period 1980-1985 is about half the capacity of Big Bend Unit 4. Consequently, uprating of older TECO units is not considered a viable alternative to construction of Big Bend Unit 4.

3.1.4 REACTIVATION OF RETIRED FACILITIES

TECO does not have any retired units that could be activated as an alternative to Big Bend Unit 4, and it does not plan on any retirements during the time span of concern.

3.1.5 JOINT PROJECTS WITH ADJACENT UTILITIES

As discussed in Section 1.3, TECO is pursuing joint ownership in future expansion in order to realize economy of scale. Several such units are currently planned by other Florida utilities for on-line service in the mid-1980s. TECO has negotiated a contract with Florida Power and Light Company (FP&L) for the sale of power from Big Bend Unit 4 on a decreasing annual basis for the first three years of operation. The capacity to FP&L will be in accordance with the schedule of need as determined by FP&L, but will not exceed an amount set by TECO. This will allow TECO to ensure reliable service to its customers. The amount of Big Bend Unit 4 capacity that will be available to FP&L is approximately 70, 50, and 25 percent for the years 1985, 1986, and 1987, respectively (Tampa Electric Company 1980).

3.1.6 CONSTRUCTION OF A SMALLER FACILITY

The construction of a smaller facility could entail a reduction in size of the planned coal-fired unit or construction of an alternative smaller unit such as a gas turbine. While a smaller unit can be constructed more quickly, the cost per megawatt is usually very high. The availability of alternative oil or gas fuels is also a questionable factor, as discussed in Section 3.2. An additional consideration is the new source performance standard of the U.S. Environmental Protection Agency (EPA), which requires scrubbing of all new boiler emissions and the historical performance of flue-gas-scrubbing equipment. Excess flue-gas-scrubber capacity may be necessary to maintain the baseload capability of the proposed generating unit in the event of a scrubber malfunction requiring shutdown for maintenance. The additional scrubber costs may have a smaller per-unit energy impact in larger plants.

3.2 POWER GENERATION ALTERNATIVES*

3.2.1 INTRODUCTION

As part of the initial planning process, TECO conducted a generation expansion study to identify the fuels and technologies that could be used to generate electric power. At present, possible resources for electric power generation include geothermal power, fuel cells, hydroelectric and pumped storage, solar thermal power, photovoltaic cells, municipal solid wastes, fuels from biomass, wind power, magnetohydrodynamics, coal gasification, coal liquefaction, fusion power, oil, natural gas, nuclear (uranium) power, and coal. These and certain other alternatives are discussed in the following sections.

3.2.1.1 Geothermal Technology

At geologically favorable sites, geothermal power generation has been found to be reasonable and competitive with other commercial sources of energy. The 608 megawatts of installed geothermal capacity in the Geysers area north of San Francisco, California, represents the sole commercial electric power application of geothermal energy in the United States. Another 600 megawatts of capacity are expected to be installed before 1983. At Cerro Prieto, Mexico, 75 megawatts of geothermal capacity are provided by utilizing hot brine from reservoirs 2,000 feet deep.

Future plants are planned at Heber, California, Valles Caluera, New Mexico, and Roosevelt Hot Springs, Utah. The eleven westernmost continental states, Texas, Louisiana, Alaska, and Hawaii are the only states with presently known suitability for geothermal energy.

Florida is not in an area where geopressured fluids are known to exist. Consequently, geothermal power generation was not considered by TECO for future generating capacity.

3.2.1.2 Fuel Cells

Fuel cells extract hydrogen from fossil fuel and combine it with oxygen to produce water, heat, and direct-current electricity. This direct conversion from chemical energy to electric energy is a much more efficient use of the input fuel (oil or natural gas), and, at the same time, most of the effluent problems associated with thermal electric powerplants can be eliminated. Advanced fuel cell concepts have a direct fuel efficiency of around 45 percent. Much higher efficiency may be possible, however, if the waste heat is utilized for space heating or industrial applications. The only waste streams from the fuel cells are the fuel residue, water, and relatively small amounts of heat. Consequently, the handling of wastes should pose minimal environmental problems to the facility environs. This characteristic would permit the siting of these facilities adjacent to load centers, thereby reducing transmission line requirements and losses. Fuel cells have nearly constant efficiency over a broad load-level range and thus can be operated at variable output to match daily load cycles without sacrificing fuel efficiency. Fuel cells would be built in relatively small (multimegawatt) modular units; hence, much shorter construction lead times would be needed for plant development, allowing a closer matching of system capacity to system load.

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*Tampa Electric Company (1980).

There are no commercial power applications of fuel cells at the present. However, 65 pilot 12.5-kilowatt units have been successfully tested by utilities in Japan, Canada, and the United States. A 4.8-megawatt fuel cell under development by United Technologies Corporation in cooperation with the Department of Energy (DOE) and the Electric Power Research Institute (EPRI) was projected to be commercially available in the early 1980s. A goal of 1985 has been set for production of second-generation fuel cells with high efficiency and a wider range of usable fuels.

Fuel cells are currently dependent on naphtha (oil) or natural gas as input fuels, but national policy discourages the use of either in baseloaded powerplants. The basic research to produce a second-generation fuel cell has not been done. Therefore, development of this technology was considered too uncertain for TECO to consider it as a reasonable alternative for meeting near-term energy requirements.

3.2.1.3 Hydroelectric and Pumped Storage

The topography and geology of Florida preclude any possibility of a hydroelectric and/or pumped-storage facility of reasonable size. Consequently, hydroelectric and pumped storage were not considered viable alternatives for future baseload electric power generating facilities.

3.2.1.4 Solar Thermal Technology

There are a variety of feasible approaches for utilizing the sun's energy to drive turbine generators. One approach would employ flat-plate collectors similar to those used in space heating to heat a heat transfer medium (Freon or other hydrocarbon) to a temperature of about 270°F for powering a specially designed turbine generator. Another approach would be to construct a network of pipes coated with a film having a high absorptivity in the visible light range and low emissivity in the infrared range. A system of Fresnel lenses or parabolic mirrors could be used to focus the sun's rays onto this pipe to heat the heat transfer media. Liquid metal, fused salts, or other working fluid flowing in the pipe, heated to temperatures of up to 1,000°F, would serve to flash water to steam for use in a conventional steam turbine. The "power tower" (central receiver) concept is the approach receiving the most attention, however. A large field of parabolic mirrors would continuously track the sun and focus its radiant energy onto an elevated receiver or boiler. The very high temperatures thus produced could be used to directly flash water to steam or to heat a molten salt within a thermal storage system that could in turn be used to provide heat for steam production on a continuous basis.

The use of a solar-thermal central station for power production has not yet been demonstrated. However, DOE and EPRI are jointly developing a 10-megawatt central receiver pilot plant, with initial plant operation set for the early 1980s. Plans call for a 100-megawatt demonstration plant in the mid-1980s and a 100-megawatt prototype commercial plant in the 1990s.

When solar-thermal power conversion has been shown to be technically feasible and economically competitive with other power sources, consideration must then be given to its environmental impacts. The most notable impacts would be the large land area (many square miles) required for a baseload facility and the aesthetic impact of the solar collection system. There are too many unknowns concerning the technical and economic feasibility and the environmental impacts of solar-thermal power production for this approach to be considered a reasonable alternative to the proposed generating facility.

3.2.1.5 Photovoltaic Cells

Photovoltaic cells employ the special characteristics of silicon crystals to convert light directly into direct-current electricity. This technology, which has found many applications in the U.S. space program, is beginning to be used for many terrestrial energy needs where power requirements are small and traditional power sources are inaccessible. A photovoltaic cell constructed of dissimilar metals and employing "thin film techniques" offers considerable promise. The production method lends itself to mass production with all its attendant cost advantages, but considerable development is required. Photovoltaic cells are currently produced by techniques that are quite costly. Consequently, the construction of central station powerplants utilizing this technology are not currently economically feasible. Although DOE is engaged in a research program to produce lower-cost solar cells, there is no assurance that the required cost reductions can be obtained in time for photovoltaic cells to economically provide new baseload capacity by the 1990s. A photovoltaic powerplant, like a solar thermal plant, would require large land areas, resulting in potentially significant environmental impact. Consequently, TECO concluded that photovoltaic cells could not be considered a reasonable alternative to the proposed facility.

3.2.1.6 Municipal Solid Wastes

Substantial sources of energy potentially exist in the large quantities of refuse generated each year in the United States. The total animal and urban solid wastes available at a reasonable collection cost are estimated to range from 4×10^7 to 6×10^7 ton/yr of dry organic material (5 lb/d per person in urban regions). The average heat content of the dry organic material is estimated to be 8,000 Btu/lb, providing an annual energy supply ranging from 6×10^{14} to 1×10^{15} Btu, which is approximately 6 percent of the nation's present generating requirements.

The use of municipal solid waste as an alternative energy source was considered by TECO to be limited by stringent air quality standards and by the lack of a viable collection and preparation system. Emission problems of an incinerator are generally more severe than those of conventional fossil-fueled plants because of variety of materials that are present. Municipal solid waste has also been shown to be less economical than conventional fuels such as coal. TECO concluded that combustion of municipal solid waste was not a reasonable alternative in view of its costs, size limitations, and environmental implications.

3.2.1.7 Fuels from Biomass

The possible methods of producing fuels from biomass, include anaerobic digestion of waste organics to produce methane; cultivation of energy crops for direct combustion or for anaerobic digestion; pyrolysis of waste or cultivated organics to produce fuel oil, low-Btu fuel gas, and tars; and mining of landfills to extract naturally formed methane. Active experimentation is being conducted in several of these areas in hopes of utilizing the large quantities of municipal and agricultural organic wastes available.

None of the projects under development presently show promise of providing the quantities of fuel needed to operate a baseload electric generating facility at a cost competitive with fossil fuels. Methane, a low-Btu fuel gas, and fuel oils produced from biomass could serve as substitutes for natural gas and fuel oil; however, their use as utility boiler fuels would most likely be preempted by other higher priority uses.

3.2.1.8 Windpower

The wind has been used as a source of power for generation, particularly for pumping water and (before the Rural Electrification Administration) for generating electricity for farms. However, they do not, as yet, represent a proven alternative to conventional baseload generation facilities even though the DOE has funded several small wind generators and recently funded a 10-megawatt multiunit system scheduled for completion in the mid-1980s. Based upon the current state of development and the timetable for future tests, it is unlikely that windpower will be able to provide large amounts of baseload capacity in the near future.

3.2.1.9 Magnetohydrodynamics

A magnetohydrodynamic (MHD) generator produces a large direct current by venting gases at high temperatures and velocities through a duct passing through a strong magnetic field. This generation technique combines the advantages of high temperature yield and relatively few moving parts; thermal efficiency is maximized and mechanical losses minimized. The result is an overall power-conversion efficiency of 40-50 percent compared to an efficiency of approximately 35 percent for conventional powerplants.

To date, researchers have been unable to develop materials that can withstand the corrosiveness of the high-temperature, high-velocity gas streams utilized in an MHD generator for any significant length of time. Additionally, major advances in the development of a superconducting electromagnet will be required if the full potential of this technology is to be realized. Solution of these problems, as well as the scale-up problem of reducing component costs, will require considerably more research and time. Therefore, MHD cannot be considered a viable alternative for commercial power generation in the near future.

3.2.1.10 Coal Gasification

Coal gasification pilot plants have been constructed and a commercial process might be available by the mid-1980s. While this method appears to be a promising alternative for fueling large central power stations, it has not been developed to the extent that it is likely to be a viable alternative to the Applicant's proposed facility.

3.2.1.11 Coal Liquefaction

Development of coal liquefaction processes has not progressed to the same extent as development of coal gasification processes. While one or more processes might be commercially available by the late 1980s, this schedule is not consistent as an alternative to the Applicant's proposed facility.

3.2.1.12 Fusion Power

Construction of a demonstration nuclear fusion plant is not expected before about 1990, and a commercial power station is not expected to be available before the year 2000. Therefore, TECO does not consider fusion power to be a viable alternative to the Applicant's proposed generating facility.

3.2.1.13 Oil and Natural Gas

The current national policy is discouraging the use of residual fuel oil and natural gas as boiler fuels in baseload generating facilities, and DOE is pushing conversion of existing units to coal utilization. Thus these fuels cannot reasonably be considered for use in new large-scale electrical generating facilities.

3.2.1.14 Nuclear Technology (Uranium)

The lead time required for licensing, design, and construction of a nuclear-fueled generating facility is presently close to 10 years. As a result of the Three Mile Island incident, the future schedule for the licensing of proposed new units is largely conjectural. The power from TECO's proposed generating facility is needed by the mid-1980s; therefore, nuclear fuel was not considered a viable alternative.

3.2.1.15 Coal

Coal remains the most viable energy alternative, and TECO has established an adequate supply for the next 10 years (Tampa Electric Company 1980). However, all new coal-fired boilers will require flue-gas cleaning to reduce emissions. The introduction of such equipment at other facilities has resulted in reduced reliability, solid-waste-disposal problems, and increased capital and operating costs.

3.2.1.16 Possible New Developments

There are a number of other alternative energy sources, such as the importing of foreign liquefied natural gas, the extraction of fuel oil from oil shale and tar sands, or the utilization of ocean thermal gradients. A variety of technical, economic, and institutional obstacles make the development of these sources very uncertain. In addition, they would most likely be used to reduce oil imports and hence are not considered reasonable alternatives to the proposed generating facility.

3.2.2 SUMMARY

After evaluating alternative fuels for a large baseload electric power generating facility, the only energy sources potentially considered by TECO for near-term application were coal and uranium. The value of other technologies as alternatives to coal and uranium is directly dependent upon their availability. Some of these alternatives may not be commercially feasible, or even technically reliable, before the late 1990s.

3.2.3 CONCLUSION

The declining domestic reserves of oil and natural gas, coupled with the uncertainty surrounding the price and availability of these imported materials and questions related to nuclear safety, has resulted in a national emergency policy encouraging the increased use of coal as the primary fuel for future power generation. In view of this national policy, it is assumed that coal or uranium will be the fuel used in TECO generating facilities for the foreseeable future. The limited time for construction of the proposed generating unit precludes consideration of nuclear fuel, however, leaving coal as the only energy alternative.

3.3 SITE ALTERNATIVES

A comprehensive, methodical process was used by the applicant to identify suitable sites for the proposed generating unit and to select a preferred site from the various alternatives identified. The site selection process began with the establishment of environmental and engineering criteria for evaluating large areas to determine if they contain potential sites for the generating unit. Next, the region of study was defined and divided into 1,440-acre areas. Each area was evaluated with respect to major environmental criteria for plant siting, and additional criteria were applied as a second screening step. From the areas which survived the two screening steps, 13 potential plant sites were selected. These sites were then comparatively evaluated to arrive at the final site selection.

3.3.1 SITING CRITERIA AND CONSTRAINTS

3.3.1.1 Criteria

Five environmental criteria were used for the initial screening of the entire study region to determine the suitability of specific site areas. The criteria included the following:

- Water quality/quantity
- Air quality
- Land-use compatibility
- Ecological quality
- Geotechnical suitability

A four-level rating scale was used to determine the favorableness of each area, the ratings ranging from "favorable" to "restricted." The rating scale was based on the degree of modification and the importance of the modification that would result from siting of the proposed facility.

For the second-stage screening, the criteria used were related to site requirements. These criteria included the following:

- Distance to connection with the Applicant's transmission system
- Availability of existing transmission facilities with adequate capacity
- Alternative transmission route to the system
- Alternative modes of fuel delivery
- Stability of generator connection to the system

Additional criteria relative to the availability of cooling water and land were then applied to the most favorable areas to define specific sites.

3.3.1.2 Region of Study

The Applicant's service area, shown in Figure 3-1, includes Hillsborough County and portions of Polk and Pasco Counties. The site-selection study covered not only Hillsborough County, which contains the Applicant's major load centers, but also the adjacent counties of Polk, Pasco, Pinellas, Manatee, and Hardee. All counties included in the study were considered in their entirety, without regard to the Applicant's service area. As shown in Figure 3-1, the total area considered extends well beyond the service area.

3.3.1.3 Initial Screening

The entire six-county area was subdivided into square elements with dimensions of 1.5 miles (i.e., areas of 1,440 acres each). Each geographical section was then evaluated against each of the five environmental criteria and ratings were assigned.

3.3.1.3.1 Water Quality/Quantity

In evaluating water quality/quantity, the various potential sources of water for cooling were considered together with a type of cooling system. Cooling-water sources in the region include the following:

- Saltwater from Tampa Bay or the Gulf of Mexico
- Freshwater from rivers
- Freshwater from lakes or impoundments
- Freshwater from wells or springs
- Nonpotable water from wells or springs
- Treated wastewater from municipal and/or industrial treatment plants

Cooling systems were specified as once-through systems, cooling ponds, or cooling towers. (Type specification is necessary because it is the factor which determines the amount of water and land required; however, no detailed design studies were undertaken.) Ratings of water quantity and quality included the following:

- Favorable--The water resource can easily meet demands of the powerplant.

- Potentially Favorable--The water resource can meet demands of the powerplant; however, the capacity of the resource is stretched.

- Potentially Favorable with Conditions--The water resource can meet demands of the powerplant; however, it would be relatively expensive to use the resource.

- Restricted--The water resource cannot consistently meet demands of the powerplant.

3.3.1.3.2 Air Quality

Air quality criteria in the screening process including Federal, state, and local ambient air quality standards; regulations of the U.S. Environmental Protection Agency regarding the prevention of significant deterioration of air quality; the location of nonattainment areas; the location of heavily industrialized areas and other major sources of air pollutants; and the location of airports.

On the basis of these criteria, the rating categories were defined in the following manner:

- Favorable--The powerplant can comply with all regulations and conditions that affect siting, with a minimum of meteorological and other source influences.

- Potentially Favorable--The powerplant can comply with all regulations and conditions affecting siting pending modification or additional study of certain outside influences.

- Potentially Favorable with Conditions--The powerplant cannot be located in the area without considerable effort to modify regulations or conditions affecting the siting.
- Restricted--The powerplant cannot be located in the area.

The "restricted" rating was assigned to areas that are within or adjacent to nonattainment areas, those in the vicinity of other sources of pollution, and those with other serious disadvantages.

3.3.1.3.3 Land Use

The land-use evaluations were based on existing rules and regulations associated with use of the land. Ratings ranged from "favorable" (no regulations that would preclude the use of land for a power plant site) to "restricted" (areas heavily regulated). The "restricted" designation was applicable to urban areas, parks and preserves, national forests, wildlife refuges, etc. Two intermediate ratings were also assigned where appropriate.

3.3.1.3.4 Ecological Quality

The ecological quality of an area was established in terms of the following factors:

1. Productivity of the systems on the site--Biological productivity, or the amount of biomass typically produced by the biological systems in the area under consideration
2. Species diversity as an indicator of the ecological "health" of the systems on the site--The diversity of the population, hence the maturity of the system and the value that can be placed on it
3. Presence of critical habitats of rare and endangered species--The existence of habitats having a rather high probability of harboring rare and endangered species
4. The relative uniqueness of the habitat on the site--The commonness and the geographic extent of areal habitats and biological systems
5. Geotechnical considerations--The existence of natural sinkholes, the likelihood of developing sinkholes or caverns, and the proneness to flooding

Ratings for the first four of the above factors ranged from "favorable" (areas containing those systems that are least sensitive to powerplant siting) to "restricted" (areas containing systems considered to be very sensitive to plant siting). Only "favorable" or "potentially favorable" ratings were used for the fifth factor, as neither sinkholes nor proneness to flooding were sufficient in themselves to rule out a specific site.

Following the assignment of ratings for the individual environmental criteria listed above, the results were compiled and an overall rating assigned for each 1.5-mile-square area. The rating assigned to an area was the lowest (least favorable) of the five ratings for the five environmental criteria. Figure 3-2 is a map showing the composite ratings.

3.3.1.4 Second-Stage Screening

The second set of site-selection criteria related to the economical and reliable operation of the generating unit as part of the TECO system. At issue were the need to connect the unit into the existing TECO transmission grid and deliver power to the loads and the need to transport coal to the unit. Minimizing transmission line length minimizes the need for land and other resources and enhances electrical system stability and reliability. Diverse modes of fuel delivery (barge and rail) are desirable for reasons of reliability and economy.

Evaluation of the five-county area with respect to these criteria showed that the preferred areas are near the Applicant's main load center (the City of Tampa), in or near the phosphate area of eastern Hillsborough and western Polk Counties, and along or near the eastern shore of Tampa Bay. Central Polk County is a less favorable area, but it is still acceptable.

3.3.1.5 Site Selection and Evaluation

Numerous 1.5-mile-square elements received either a "favorable" or "potentially favorable" rating with respect to all criteria in both stages of the screening process. Eight areas were found to contain at least five contiguous elements with such ratings. These areas are all inland, and freshwater cooling is indicated. Two coastal areas, in which saltwater could be used for cooling, were also identified as potential site areas. Figure 3-3 shows these potential site areas.

Within the 10 areas selected at the culmination of the second phase of screening, numerous potential plant sites were discovered. These areas were examined in detail with respect to the existence of cooling-water sources and large land holdings to identify a number of possible plant sites for further evaluation.

Water sources identified include streams, lakes, and discharges of treated wastewater from industrial facilities, farms, and municipalities. Abandoned quarries represent another source of cooling water, and they have possible application as cooling ponds.

Land availability is most restricted in the two coastal areas. In the Pasco County area, no single-owner tracts of sufficient size for powerplant siting were found. On the eastern shore of Tampa Bay (the other coastal area), only two tracts were found, the existing Big Bend site and the MacInnes site, both owned by the Applicant. In addition, three potential sites were identified in Area 3, two in Area 2, and one in each of the other areas. Preferred sites within the preferred areas are shown in Figure 3-4.

The 13 sites thus identified were subjected to detailed evaluation. The nature and results of this evaluation are discussed in Section 3.3.2.

3.3.2 ALTERNATIVE SITE COMPARISONS

3.3.2.1 Ranking the Candidate Sites

In order to evaluate the relative suitability of the candidate sites, 21 siting characteristics were identified to serve as the basis for comparison. This list of criteria was developed by an interdisciplinary team of scientists and engineers, who took into consideration the essential characteristics of a powerplant site. This same team then judged the relative importance of each criterion. This initial system of weights--they range from 1 to 5, with 5 indicating greatest importance--was then reviewed and reevaluated until consensus weights were obtained for all criteria (Table 3-1).

Each site was then rated for each criterion by consultants with expertise in that particular field. These ratings were based on site visits and secondary data sources. The ratings ranged from 1 to 5, with 5 indicating highest suitability for that criterion. Site scores were obtained by multiplying this rating by the weight for each criterion. These values were then summed for all criteria for a site to yield a total site score (Table 3-2). The higher the numerical score, the more suitable the site.

The total site scores indicate that Site 8A (Big Bend) is significantly more suitable than the other sites. Sites 7, 2, and 3A form a group as the next level of suitability.

3.3.2.1.1 Sensitivity Analysis

Because of the subjectivity inherent in the weighting/rating system for the sites, a sensitivity analysis was performed to explore the effects of variations in input data on the site suitability scores and on the overall rankings. This analysis demonstrated the degree to which selection of the recommended site was affected by reasonable changes in the weighting and rating systems.

Ratings and weights in the sensitivity analysis were changed after a thorough reexamination by the project team of all rating/weighting assignments. Reasonable extremes in the weighting system can be established by having the weights modified in favor of either environmental concerns or construction/operational concerns. The two test weighting systems developed and the original weighting system are shown in Table 3-3. The original ratings were reviewed for all criteria in order to identify the highest and lowest reasonable ratings for the alternative sites. All possible rating increases were entered as Rating Change A, and all possible decreases were entered as Rating Change B. These rating changes are shown in Tables 3-4 and 3-5, respectively.

On the basis of input from the two modified sets of weights and the two rating changes, together with the original weights and ratings (Table 3-2), eight alternatives to the original analysis could be developed.

The comparison of the site suitability scores under the nine different combinations of weights and ratings is summarized in Table 3-6.

The result of this analysis was that Site 8A is the preferred site, with Sites 7 (Peace Creek) and 2 (Highland) ranked as second and third, respectively. This analysis demonstrated the insensitivity of the recommended site to significant modification of inputs to the site suitability calculations.

3.3.2.1.2 Cost Analysis

The objective of this aspect of the screening was to identify the most cost-effective candidate site for the proposed facility. As a result of the ranking of candidate sites and the sensitivity analysis, three sites were identified as "preferred." These were Sites 8A, 7, and 2 in order of their ranking. An analysis was then performed to determine the costs of constructing and operating powerplants at each site. Capital costs, estimates of annual or recurrent costs, and total annual costs above the base case are presented in Table 3-7.

The results indicate that Site 8A is the most cost-effective site and, therefore, the preferred site for the proposed facility by this analysis.

3.3.2.1.3 Fatal-Flaw Analysis

Site 8A is indicated by the selection process as the preferred site for the location of the 417-megawatt unit. This site presently contains three similar units, which use water from Tampa Bay for once-through cooling. The Applicant proposes that this additional unit will also use the once-through cooling system.

An alternative for the site is the use of saltwater cooling towers. According to the present analysis, the towers would add to the cost, visual impact, and maintenance of the proposed facility. The saltwater cooling towers for the site should be designed for drift control to prevent possible negative effects on nearby agricultural and natural systems. Inability to design the towers for adequate drift control could constitute yet another fatal flaw. In that case, an alternative source of cooling-tower makeup water such as nonpotable ground water or sewage treatment plant effluent could be considered.

The site selection process has shown Site 8A to be the preferred site, based upon a balance between engineering/operations, environmental, and socioeconomic factors. The alternative sites in central Polk County have a limited amount of water available to them. The potential need to augment the treated wastewater source with ground water and/or surface water may represent a fatal flaw for Site 7. The Southwest Florida Water Management District is on record as opposing the use of ground water for powerplant cooling and is reluctant to approve the use of fresh surface water for this purpose.

Additional fatal flaws may exist for Site 7. There is the possibility that an agreement cannot be made with the City of Winter Haven to use their treated wastewater. If an agreement could be reached and the powerplant is built, it would be effectively concentrating the wastewater and discharging it into the environment. Any toxic materials or other pollutants present at low levels in the wastewater would be concentrated possibly beyond water quality standards, creating a disposal problem.

If cooling ponds are constructed in central Polk County, "waters of the United States" will probably be involved. The pond could become a cooling lake and possibly "waters of the United States" and hence require a Section 316 Demonstration study and imposition of effluent guidelines on plant discharge to the pond rather than discharge from the pond.

Site 2 would make use of Lake Hancock, which would require Section 316 studies and would encounter the conceptual opposition of both Federal agencies and the Southwest Florida Water Management District. Lake Hancock may not be as reliable a source of water as will be needed over the 35-year life of the plant; an emptying of the lake into underground caverns occurs at irregular intervals. While drainage control structures could be emplaced on the lake bottom, such structures might disrupt the biological and human systems that depend on the lake. This represents a potential fatal flaw for the Highland site.

3.3.2.2 Ultimate Generating Capacity of Candidate Sites

An analysis of the ultimate generating capacity of coal-fired facilities at all candidate sites other than Big Bend was also performed. The principal criteria for this analysis were air quality, water quantity/quality, and land availability.

Based on the individual assessments for the principal criteria, the ultimate power generation capacity of each site was determined (Table 3-8). This task involved only the air quality and water availability criteria; the land area availability criterion was not considered a limiting factor because adjacent to each site there is available land sufficient to accommodate facilities expansion. Potential ultimate capacity was determined by selecting the lowest capacity based on the combined air quality and water availability data. In the case of Site 1, for example, air quality would allow for up to 2,100 megawatts, but water availability would limit production to 940 megawatts. Accordingly, the considered potential ultimate capacity of the site is 940 megawatts.

The potential versus the actual ultimate capacity of each site was also an important consideration. A site could have a potential ultimate capacity of 1,400 megawatts and yet fail to achieve that capacity by virtue of the nonavailability of specific power-plant combinations. The addition of an 800-megawatt unit to a base 500-megawatt unit--a desirable combination in view of air quality impact priorities—would yield only 1,300 megawatts, and there would be no feasible means of providing the additional 100 megawatts. In short, actual ultimate capacity is commonly somewhat lower than potential ultimate capacity.

Table 3-9 presents the real ultimate capacity of each site identified in the Stage I regional screening analysis. Sites 3B, 3C, 4, and 6 have slightly reduced ultimate capacities because of the considerations presented above. Site 10B is significantly reduced in ultimate capacity due to the fact that the first unit is considered to be a 500-megawatt facility. No additional units can be accommodated at this site, even though the site has the potential of over 350 megawatts of additional capacity, based on air and water requirements and limitations.

3.3.2.3 Summary

The site selection process consisted of three stages. In the first stage, an area-wide screening process for general environmental suitability was accomplished. This screening was used to identify favorable and restricted areas for siting within the six-county area. The favorable areas were then subjected to further screening based on site requirement considerations, and 13 candidate sites were identified. In the second stage, the candidate sites were evaluated and ranked by their favorability for siting according to environmental and site requirement criteria. Based on this analysis, the three most favorable or prime sites were identified. The third stage consisted of three phases: (1) a sensitivity analysis of the methodology to determine how possible changes in the subjective evaluations would affect the recommendation of the most favorable site; (2) a detailed engineering cost analysis to establish a ranking of the three prime sites; and (3) a detailed licensability analysis of the most favorable site to verify the existence or nonexistence of fatal flaws.

3.3.2.4 Conclusion

On the basis of the various criteria established for the siting study, the Big Bend site was clearly identified as the preferred location for construction of the proposed 417-megawatt coal-fired powerplant.

Table 3-1. Siting characteristics and relative weights

Siting criterion	Weight
Engineering/economic considerations	
Cooling water supply	5
Plant service water	3
Rail accessibility	4
Highway accessibility	3
Port accessibility	5
Transmission line proximity	4
Site preparation	3
Environmental characteristics	
Terrestrial ecology	3
Aquatic ecology	4
Rare and endangered species	5
Sulfur dioxide	4
Particulates	4
Other air pollutants	3
Surface-water quality	2
Ground-water quality	3
Socioeconomic considerations	
Archaeological resources	4
Land-use compatibility	4
Land availability	5
Aesthetics	2
Regional economics	3
Community impact (demographic)	2

Table 3-2. Summary of site suitability

Criterion	Criterion weight	Ratings of alternative sites[a]												
		1	2	3A	3B	3C	4	5	6	7	8A	8B	10A	10B
Cooling water supply	5	2	5	5	3	3	3	1	3	3	5	5	5	3
Plant service water	3	5	5	5	5	5	5	5	5	5	5	4	5	5
Rail accessibility	4	5	5	3	5	4	5	2	5	4	5	4	2	5
Highway accessibility	3	3	5	3	4	5	2	5	5	3	5	3	5	5
Port accessibility	5	2	2	1	2	2	2	2	1	2	5	5	1	2
Transmission line proximity	4	1	4	4	4	4	3	2	3	4	5	2	4	4
Site preparation	3	2	3	4	4	4	4	3	4	4	4	2	1	1
Terrestrial ecology	3	3	5	3	4	5	4	5	4	5	2	1	3	5
Aquatic ecology	4	3	4	4	4	5	3	4	2	5	2	1	4	4
Rare and endangered species	5	3	4	3	4	4	3	4	4	4	4	1	3	4
Sulfur dioxide	4	5	4	5	5	5	5	5	5	5	4	4	5	5
Particulates	4	2	2	2	2	2	2	2	2	2	1	2	2	2
Other air pollutants	3	1	1	1	1	1	2	1	1	2	1	1	2	2
Surface-water quality	2	3	2	2	2	2	2	2	1	2	4	4	2	2
Ground-water quality	3	3	3	2	3	2	3	2	3	2	2	3	1	1
Archaeological resources	4	4	3	4	3	3	3	3	4	3	4	3	4	3
Land-use compatibility	4	5	2	4	2	1	3	3	2	4	4	5	2	1
Land availability	5	4	2	4	2	3	3	2	4	3	5	5	3	3
Aesthetics	2	4	2	4	2	2	4	2	2	3	3	4	3	2
Regional economics	3	5	5	5	5	5	5	4	4	5	5	3	5	4
Community impact	2	4	3	3	3	3	3	2	3	4	3	4	3	2
Total score[b]		243	256	256	247	251	244	211	247	264	287	239	234	237

[a] See Figure 3-4 for site locations.

[b] Sum of weights times ratings for all criteria.

Table 3-3. Variations in the weighting system[a]

Criterion	Original weight	Environmental-based weight	Construction/ operation-based weight
Cooling water supply	5	4	5
Plant service water	3	2	4
Rail accessibility	4	3	5
Highway accessibility	3	2	4
Port accessibility	5	4	5
Transmission line proximity	4	3	5
Site preparation	3	2	4
Terrestrial ecology	3	4	2
Aquatic ecology	4	5	3
Rare and endangered species	5	5	4
Sulfur dioxide	4	5	3
Particulates	4	5	3
Other air pollutants	3	4	2
Surface-water quality	2	3	1
Ground-water quality	3	4	2
Archaeological resources	4	5	3
Land-use compatibility	4	5	3
Land availability	5	5	4
Aesthetics	2	3	1
Regional economics	3	4	2
Community impact	2	3	1

[a] From Environmental Science and Engineering, Inc. (1979).

Table 3-4. Rating change A[a]

Criterion	Ratings of alternative sites[b]												
	1	2	3A	3B	3C	4	5	6	7	8A	8B	10A	10B
Cooling water supply	2	5	5	3	3	3	1	3	3	5	5	5	3
Plant service water	5	5	5	5	5	5	5	5	5	5	(5)	5	5
Rail accessibility	5	5	3	5	4	5	2	5	4	5	4	(3)	5
Highway accessibility	3	5	3	4	5	2	5	5	3	5	3	5	5
Port accessibility	2	2	1	2	2	2	1	2	2	5	5	1	2
Transmission line proximity	1	4	4	4	4	(4)	2	3	4	5	2	4	4
Site preparation	(3)	(4)	4	4	4	4	(4)	4	4	4	2	1	1
Terrestrial ecology	3	5	3	4	5	4	5	4	5	2	1	3	5
Aquatic ecology	3	4	4	4	5	3	4	2	5	2	1	4	4
Rare and endangered species	3	4	3	4	4	3	4	4	4	4	1	3	4
Sulfur dioxide	5	4	5	5	5	5	5	5	5	4	4	5	5
Particulates	2	2	2	2	2	2	2	2	2	1	2	2	2
Other air pollutants	1	1	1	1	1	2	1	1	2	1	1	2	2
Surface-water quality	3	2	(3)	(3)	(3)	(3)	(3)	1	(3)	4	4	2	2
Ground-water quality	3	3	2	3	2	3	2	3	2	2	3	1	1
Archaeological resources	4	3	4	3	3	3	3	4	3	4	3	4	3
Land-use compatibility	5	(3)	4	2	1	3	3	2	4	4	5	(3)	1
Land availability	4	2	4	2	3	3	2	4	3	5	5	3	3
Aesthetics	(5)	2	4	2	2	4	2	2	3	3	(5)	3	2
Regional economics	5	5	5	5	5	5	4	4	5	5	3	5	4
Community impact	4	3	3	3	3	(4)	2	3	4	3	4	3	2

[a] From Environmental Science and Engineering, Inc. (1979).
[b] See Figure 3-4 for site locations.

Note: Numbers in parentheses indicate revised rating.

Table 3-5. Rating change B[a]

Criterion	Ratings of alternative sites[b]												
	1	2	3A	3B	3C	4	5	6	7	8A	8B	10A	10B
Cooling water supply	(1)	(4)	(4)	(2)	(2)	(2)	1	(2)	(2)	5	5	(4)	(2)
Plant service water	5	5	5	5	5	5	5	5	5	5	4	5	5
Rail accessibility	5	5	3	5	(3)	5	2	5	(3)	5	4	2	5
Highway accessibility	3	5	3	4	5	2	5	5	3	5	3	5	5
Port accessibility	2	2	1	2	2	2	1	2	2	5	5	1	2
Transmission line proximity	1	4	4	4	4	3	2	3	4	5	2	4	4
Site preparation	2	3	4	4	4	4	3	4	4	4	(1)	1	1
Terrestrial ecology	3	5	3	4	5	4	5	4	5	2	1	3	5
Aquatic ecology	3	4	4	4	5	3	4	2	5	2	1	4	4
Rare and endangered species	(2)	(3)	(2)	(3)	(3)	(2)	(3)	(3)	(3)	(3)	1	(2)	(3)
Sulfur dioxide	5	4	5	5	5	5	5	(4)	5	4	4	5	5
Particulates	(1)	2	2	2	2	2	2	2	2	1	(1)	2	2
Other air pollutants	1	1	1	1	1	2	1	1	(1)	1	1	(1)	(1)
Surface-water quality	(1)	(1)	2	2	2	2	2	1	2	4	4	(1)	(1)
Ground-water quality	(2)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(1)	(2)	1	1
Archaeological resources	4	3	4	3	3	3	3	4	3	4	3	4	3
Land-use compatibility	5	2	4	2	1	(2)	3	2	4	4	5	2	1
Land availability	4	2	4	2	3	3	2	4	3	5	5	3	3
Aesthetics	4	2	4	2	2	(3)	2	2	3	3	4	3	2
Regional economics	5	5	5	5	5	5	4	4	5	5	3	5	4
Community impact	4	3	3	3	3	3	2	3	4	3	4	3	2

[a] From Environmental Science and Engineering, Inc. (1979).
[b] See Figure 3-4 for site locations.

Note: Numbers in parentheses indicate revised rating.

Table 3-6. Comparison of results from the weighting and rating combination[a]

Site[b]	Weighting/rating system								
	Original			Environmental			Construction operations		
	Orig	A	B	Orig	A	B	Orig	A	B
1	243	248	224	265	270	244	210	215	195
2	256	263	241	263	270	247	236	243	224
3A	256	258	243	270	273	257	229	230	218
3B	247	249	234	256	259	243	227	228	216
3C	251	253	234	260	263	244	230	231	214
4	244	252	225	259	268	238	218	225	203
5	211	216	203	227	232	218	187	192	181
6	247	247	230	253	253	235	228	228	214
7	264	266	244	281	284	261	235	236	217
8A	287	287	279	288	288	279	267	267	261
8B	239	244	229	249	254	238	213	218	204
10A	234	242	219	247	255	231	209	217	197
10B	237	237	222	245	245	229	217	217	205
Total possible score	375	375	375	400	400	400	330	330	330

[a] From Environmental Science and Engineering, Inc. (1979).
[b] See Figure 3-4 for site locations.

Table 3-7. Cost summary (millions of dollars)

Capital costs	Site 8A (Big Bend)		Site 7 (Peace Creek)		Site 2 (Highland)	
	Once-through	Cooling towers	Cooling towers	Cooling pond	Cooling towers	Cooling pond
Land	0	0	1.3	3.4	1.3	3.4
Site preparation and foundation	28	28	28	28	28	28
Plant	371	397	542	542	542	542
Coal delivery facilities	0	0	0.8	0.8	0.3	0.3
Water supply	0.3	0.3	0.4	0.4	0.4	0.4
Transmission system	0	0	7.0	7.0	5.2	5.2
Total	399.3	425.3	579.5	581.6	577.2	579.3
Annual fixed charges	57.9	61.7	84.0	84.3	83.7	84.0
Recurrent costs (annual)						
Fuel (high Btu)	50.0	50.0	53.2	53.2	53.2	53.2
Transmission system losses	0	0	0.1	0.1	0.1	0.1
County taxes	6.4	6.5	6.6	6.6	6.6	6.6
Total recurrent costs	56.4	56.5	59.9	59.9	59.9	59.9
Total annual costs	114.3	118.5	143.9	144.2	143.6	143.9
Total annual costs above base case (Site 8A, Big Bend, once-through)	0	4.2	29.6	29.9	29.3	29.6

Note: All costs, except county taxes, are in 1985 dollars. County taxes are present dollar values.

Table 3-8. Composite analysis of sites and principal criteria to determine ultimate power generation capacity[a,b]

Site	Ultimate capacity based on air quality	Ultimate capacity based on water availability			Ultimate capacity based on land availability			Additional land area available adjacent to site	Overall site ultimate potential capacity
		Once-through cooling alternative	Cooling tower(s) alternative	Cooling pond(s) alternative	Once-through cooling alternative	Cooling tower(s) alternative	Cooling pond(s) alternative		
1	2100	NA	220	940	NA	1400	500	Yes	940
2	2900	NA	NA	500	NA	NA	420	Yes	500
3A	2900	NA	NA	500	NA	NA	400	Yes	500
3B	2900	NA	540	1400	NA	650	250	Yes	1400
3C	2900	NA	540	1400	NA	650	250	Yes	1400
4	2900	NA	540	1400	NA	650	250	Yes	1400
5	2900	NA	620	1130	NA	950	350	Yes	1130
6	2900	NA	130	1460	NA	620	250	Yes	1460
7	2900	NA	NA	460	NA	NA	250	Yes	460
8B	2900	A	NA	NA	AC	NA	NA	Yes	2900
10A	2900	NA	170	1260	NA	2100	650	Yes	1260
10B	2900	NA	170	850	NA	650	250	Yes	850

Abbreviations:
NA = not applicable.
A = applicable. Site not constrained by water availability. Ultimate capacity cannot be determined.
AC = ultimate capacity cannot be determined.

[a] From Environmental Science and Engineering, Inc. (1980).
[b] All values in gross MW.

Table 3-9. Combinations of powerplant size to meet site ultimate capacity[a]

Site	Potential ultimate capacity	Combination of plant sizes 500 MW	650 MW	800 MW	Real ultimate capacity
1	940	2[b]	0	0	940
2	500	1	0	0	500
3A	500	1	0	0	500
3B	1400	1	0	1	1300
3C	1400	1	0	1	1300
4	1400	1	0	1	1300
5	1130	1	1	0	1130
6	1460	1	0	1	1300
7	460	1[b]	0	0	460
8B	2900	1	0	3	2900
10A	1260	1[b]	0	1[b]	1260
10B	850	1	0	0	500

[a] From Environmental Science and Engineering, Inc. (1980).

[b] It is assumed that generating units can be combined if by doing so the potential ultimate capacity would not be exceeded by more than 100 MW.

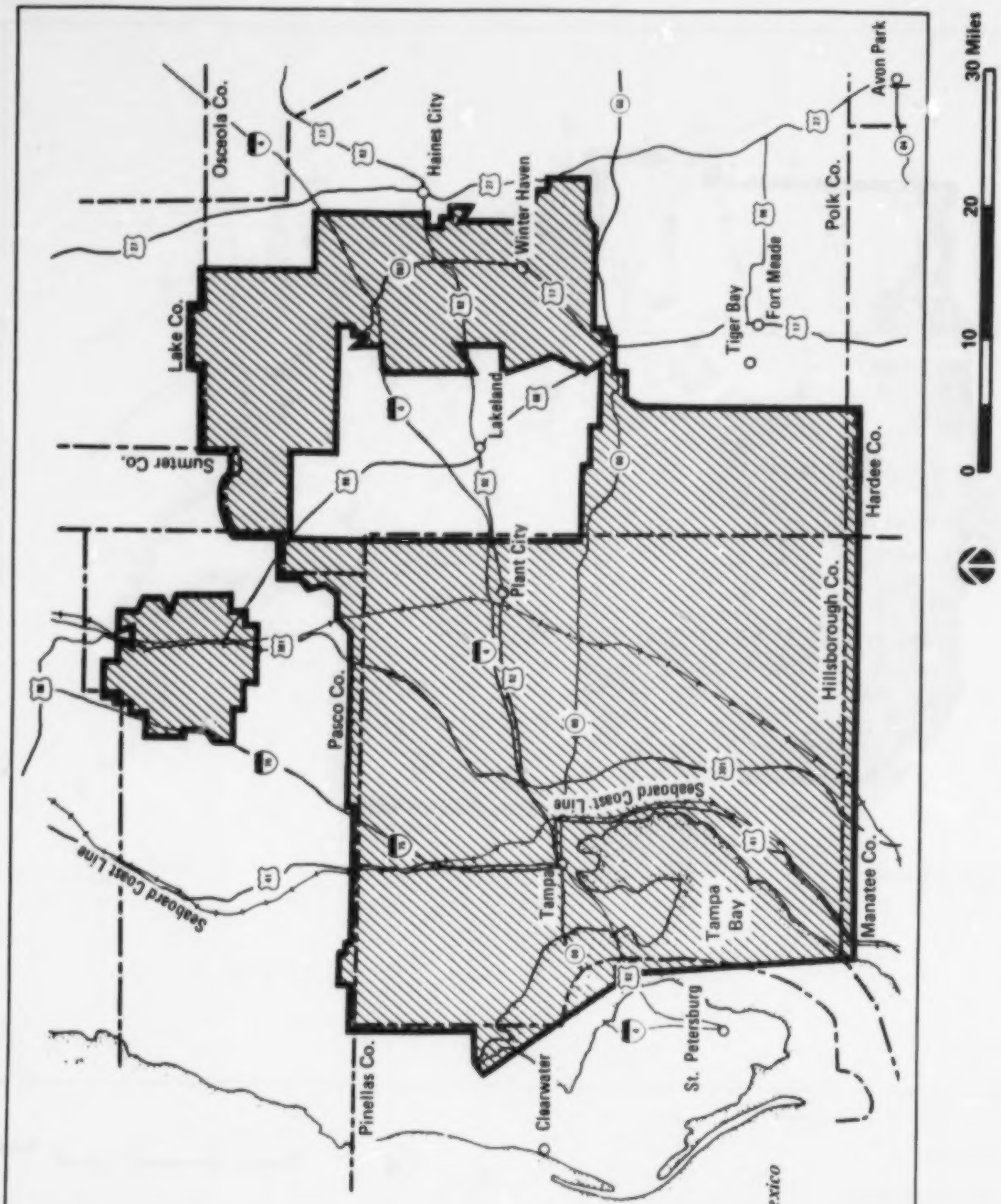
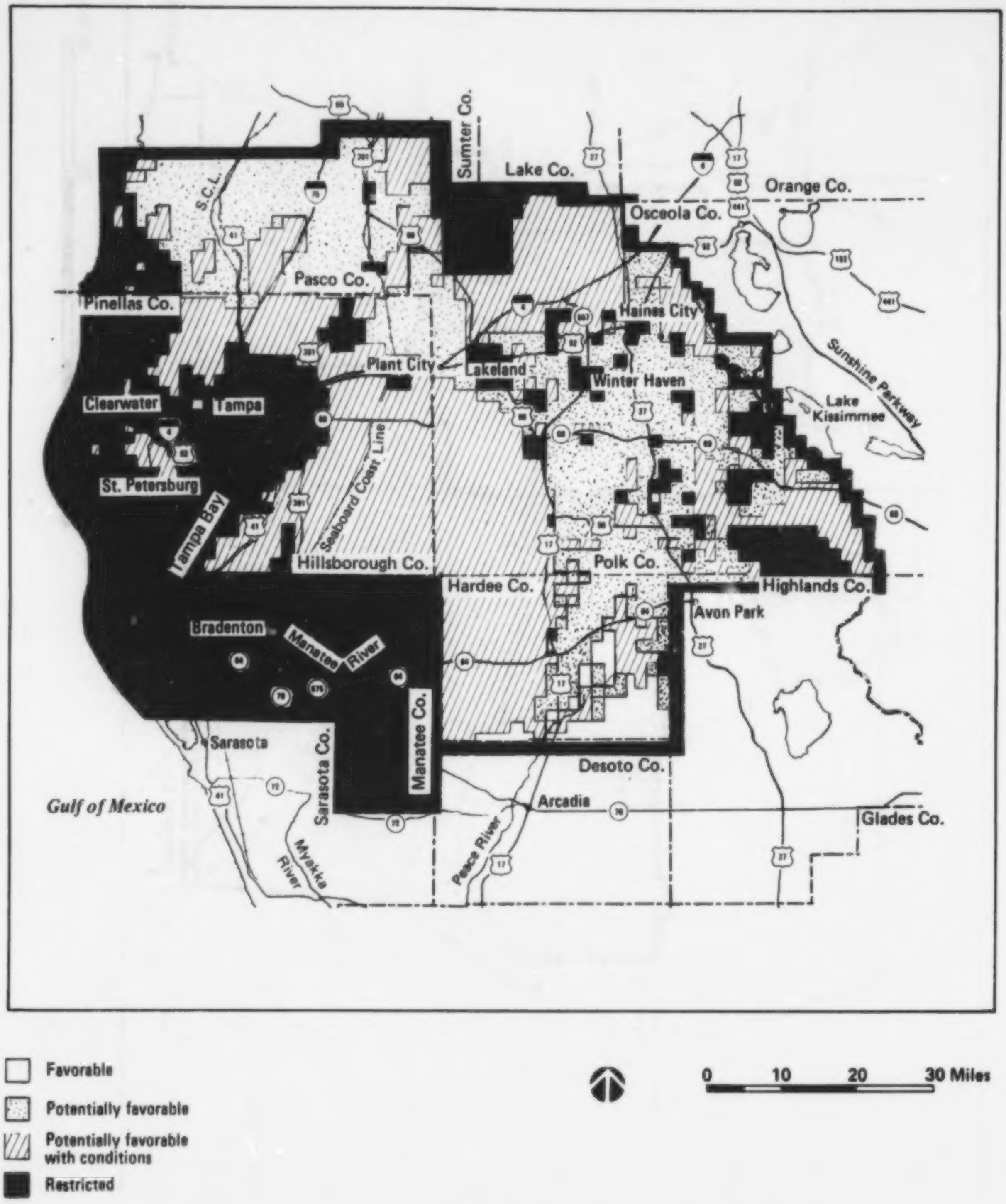

Osceola Co.
Lake Co.
Haines City
Winter Haven
Sumter Co.
Lakeland
Tiger Bay
Fort Meade
Polk Co.
Avon Park
Hardee Co.
Plant City
Pasco Co.
Hillsborough Co.
Seaboard Coast Line
Seaboard Coast Line
Tampa
Tampa Bay
Manatee Co.
St. Petersburg
Clearwater
Pinellas Co.
Gulf of Mexico
0
10
20
30 Miles

Figure 3-1. Tampa Electric Company service area.



Sumter Co.
Lake Co.
Orange Co.
Osceola Co.
S.C.L.
Pasco Co.
Pinellas Co.
Haines City
Plant City
Lakeland
Winter Haven
Sunshine Parkway
Lake Kissimmee
Clearwater
Tampa
St. Petersburg
Seaboard Coast Line
Tampa Bay
Hillsborough Co.
Polk Co.
Hardee Co.
Highlands Co.
Avon Park
Bradenton
Manatee River
Manatee Co.
Sarasota
Sarasota Co.
Gulf of Mexico
Desoto Co.
Arcadia
Glades Co.
Myakka River
Peace River
Favorable
Potentially favorable
Potentially favorable with conditions
Restricted
0
10
20
30 Miles

Figure 3-2. Environmental composite.

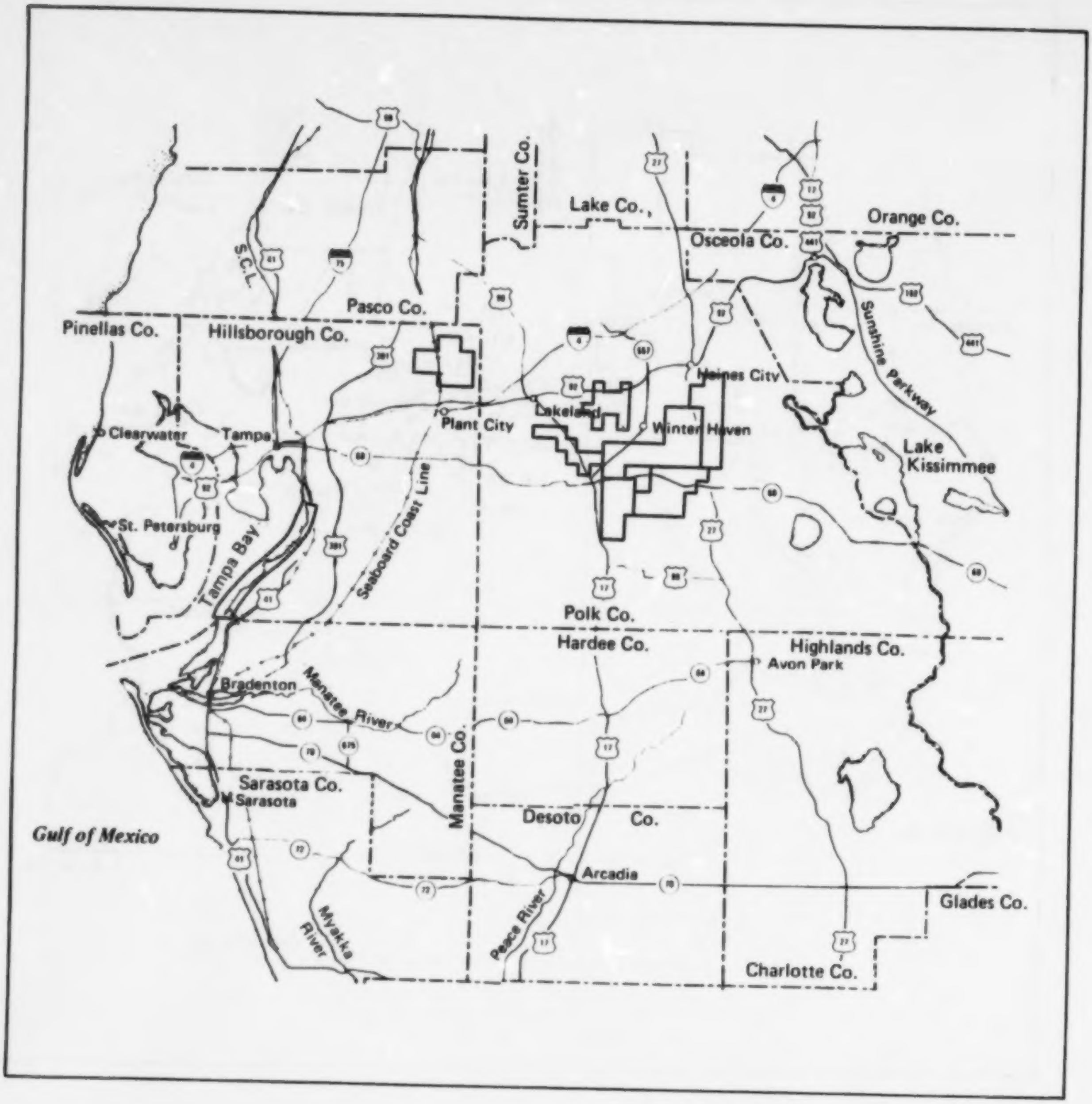

Sumter Co.
Lake Co.,
Orange Co.
Osceola Co.
S.C.L.
Pasco Co.
Pinellas Co.
Hillsborough Co.
Haines City
Lakeland
Plant City
Winter Haven
Clearwater
Tampa
Sunshine Parkway
Lake Kissimmee
St. Petersburg
Tampa Bay
Seaboard Coast Line
Polk Co.
Hardee Co.
Highlands Co.
Avon Park
Bradenton
Manatee River
Manatee Co.
Sarasota Co.
Sarasota
Desoto Co.
Gulf of Mexico
Arcadia
Glades Co.
Myakka River
Peace River
Charlotte Co.
0
12
24 Miles

Figure 3-3. Map of preferred areas.

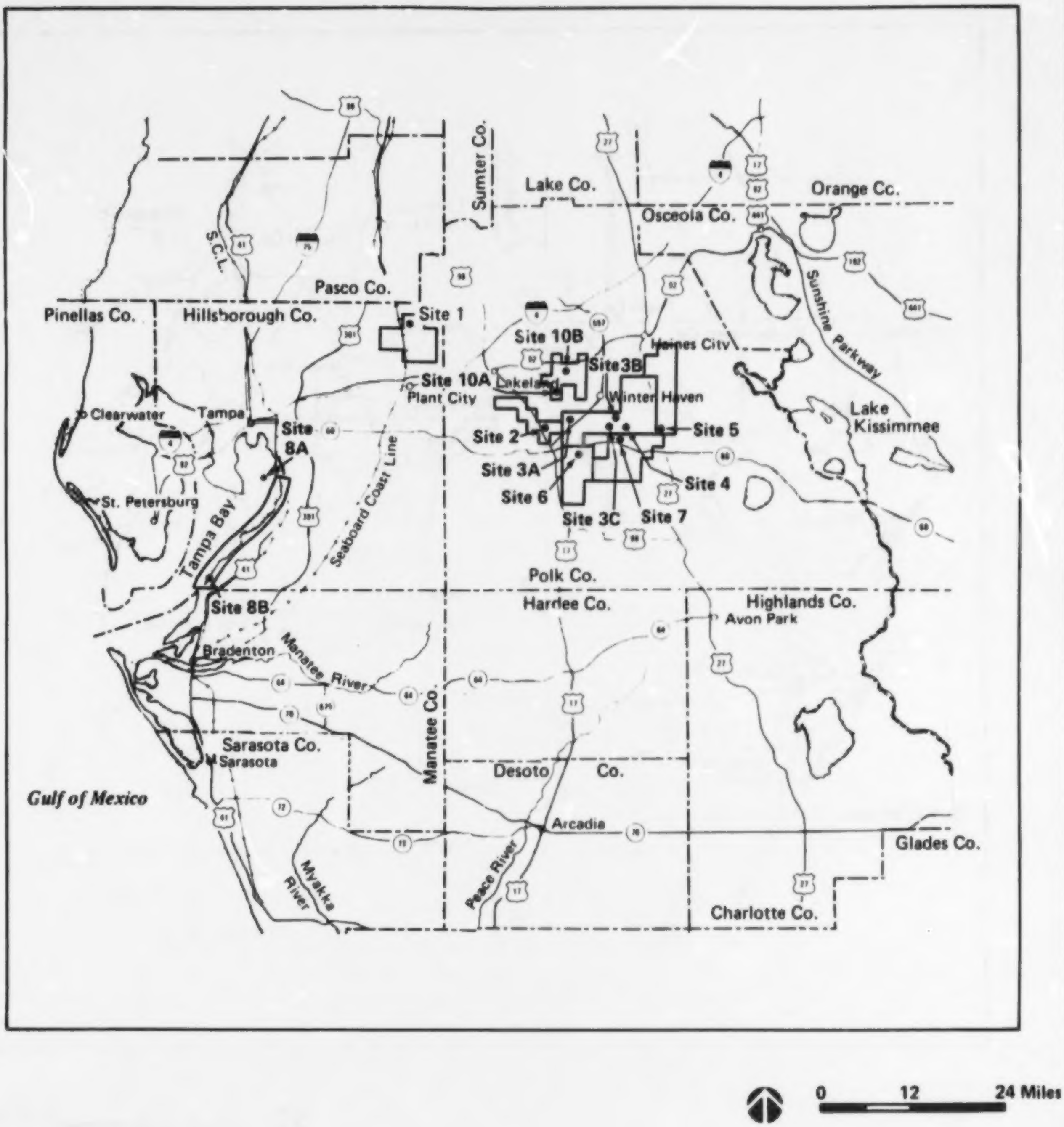

Sumter Co.
Lake Co.
Orange Co.
Osceola Co.
Sunshine Parkway
Pasco Co.
Pinellas Co.
Hillsborough Co.
S.C.L.
Site 1
Site 10B
Site3B
Haines City
Site 10A
Lakeland
Plant City
Winter Haven
Lake Kissimmee
Clearwater
Tampa
Site 8A
Site 2
Site 5
Site 3A
Site 4
Site 6
St. Petersburg
Tampa Bay
Seaboard Coast Line
Site 3C
Site 7
Polk Co.
Hardee Co.
Highlands Co.
Avon Park
Site 8B
Bradenton
Manatee River
Manatee Co.
Sarasota Co.
Sarasota
Desoto Co.
Gulf of Mexico
Arcadia
Glades Co.
Myakka River
Peace River
Charlotte Co.
0
12
24 Miles

Figure 3-4. Preferred sites relative to preferred areas.

3.4 ALTERNATIVE PLANT SYSTEMS

3.4.1 ALTERNATIVE WASTE-HEAT-REJECTION SYSTEMS

In a powerplant, fuel is burned to create heat, and the energy contained in the heat is converted to electrical energy. Elementary considerations of physics show that it is not possible in a steam plant to convert heat energy to electric energy with 100 percent efficiency. Instead, only a portion of the heat is converted to electric energy, the balance being rejected at low temperature as waste heat. The efficiency of the conversion process is maximized and the amount of waste heat is minimized by reducing the temperature at which the waste heat is rejected. Maximum efficiency is desired to minimize the amount of fuel burned and the amount of pollutants emitted. Heat is typically rejected from powerplants at temperatures below 100°F. Various methods are available for efficiently dissipating waste heat, including once-through cooling, artificial lakes or ponds, and cooling towers.

Once-through cooling requires that the plant be sited adjacent to a large body of water. Water is pumped through the plant's condenser, absorbing heat as it passes through, and is then returned to the body of water. The process raises the water temperature in the vicinity of the discharge point, but the heat is eventually dissipated to the atmosphere by evaporation, radiation, and convection, with evaporation predominating. Large flows and moderate temperature increases in the condenser are required for once-through cooling. The proposed unit would require a flow of 537 cubic feet per second (cfs) with a temperature rise of 17°F at 100 percent power.

A cooling lake or cooling pond is simply an artificial body of water that provides cooling for the plant. Water is continuously withdrawn from the pond, pumped through the plant's condensers (absorbing waste heat from the plant) and returned to the pond at a higher temperature. In the pond, water slowly circulates from the condenser discharge to the intake. As it circulates it is cooled, heat being dissipated to the atmosphere by evaporation, radiation, and convection. The temperature of the lake is determined by its surface area, the amount of heat added by the plant, and weather conditions. The lake must therefore be large enough to provide an adequately low water temperature for plant efficiency and operating economy.

In a few instances, powerplant cooling has been achieved by spraying water from the condenser into the air. Evaporative cooling is enhanced by the large surface area of the water drops in the spray and by the velocity of the drops in the air. Although this system requires less acreage than a cooling lake, it has two disadvantages: local fogging is produced under certain weather conditions and large amounts of power are required for spray pump operation.

Cooling towers for powerplant use are almost exclusively of the wet type. In this type of tower, heated water from the plant condenser is pumped to the tower and sprayed down through a moving stream of air. A system of baffles or trays (called fill) is provided to maintain the water as a thin film or as droplets over a large surface area in order to promote evaporative cooling. Water is cooled as it descends through the tower, and is collected in a basin at the bottom. From there it returns to the condenser, completing the circuit.

Cooling towers are classified as natural draft or mechanical draft. Fans are provided at the top of a mechanical-draft tower to draw air through the fill and to exhaust it upward from the tower. Mechanical-draft towers require substantial amounts of energy for fan operation. A natural-draft tower is marked by a tall structure above the fill area, usually of a hyperbolic (hourglass) shape. The temperature and humidity differences between the air in the tower and the ambient air create a chimney effect; air is drawn through the fill and upward through the tower. The warm, humid climatic conditions that occur frequently in the vicinity of the proposed plant place the natural-draft tower at a disadvantage. Natural-draft towers can approach 500 feet in height, with a diameter at the base of 300 feet for the largest powerplants. A cloudlike plume is frequently observed at the top of a natural-draft tower.

As the water cascades downward through the fill in a cooling tower, small droplets are entrained in the air stream. These droplets (called "drift") have the same content of dissolved salts or solids as the circulating water in the tower. All modern towers are equipped with drift eliminators, which are baffles or channels intended to remove drift droplets by impingement. However, no drift eliminator can be totally effective; thus, some amount of drift is exhausted from the tower. In the case of freshwater towers, drift usually is inconsequential. However, when the towers use saltwater or municipal wastewater, they can represent a significant source of airborne solids.

Dry cooling towers have been used in a very few instances where water is scarce or unavailable for powerplant cooling. In this type of system, the water to be cooled is contained inside tubes and air passes over the outside. The tubes are usually finned to promote heat transfer. Nevertheless, heat transfer is much less efficient than evaporative cooling, resulting in high waste-heat-rejection temperatures and poor overall plant efficiency.

3.4.1.1 Introduction

The region in which the proposed new generating unit is to be located offers potential for a variety of types of heat-rejection systems and sources of water. Viable heat-rejection system alternatives include once-through cooling, cooling towers, and ponds or canals. Sources of water for operation of the waste-heat-rejection systems include the Gulf of Mexico and Tampa Bay (saltwater), wells, lakes, and streams (freshwater), and sources of treated municipal wastewater. Because of the large volume of water required by the waste-heat-rejection system, the source of cooling water must be at or near the plant site. Similarly, site characteristics such as topography and available land area are key factors in determining the feasibility of various types of waste-heat-rejection systems.

During the site selection and evaluation process, sites that were suitable from the standpoint of water availability were identified. Due to the inherent restrictions imposed by particular sites, one or more heat-rejection alternatives were associated with each site under consideration, as discussed in the section on alternative sites.

The heat-rejection system proposed by the Applicant for Big Bend Unit 4 is once-through cooling with fine-mesh screening of the intake water of Units 3 and 4. The purpose of the fine-mesh screen is to minimize the entrainment and impingement of aquatic biota (Section 4.2.4). Other alternatives considered were once-through cooling with standard intake design, once-through cooling with dilution to reduce the discharge temperature, mechanical-draft cooling towers with saltwater makeup, and mechanical-draft cooling towers with treated wastewater makeup.

The proposed system was selected from among the alternatives considered on the basis of the following considerations:

1. The heat-rejection system should comply with regulations of the U.S. Environmental Protection Agency (EPA) and the State of Florida, including the requirement that Best Available Technology be utilized.
2. The heat-rejection system should allow the unit to operate at design capacity and should not adversely affect the reliability and availability of the unit.
3. The system should be compatible with existing generating units at the site.
4. Within the limitations imposed by the preceding criteria, the heat-rejection system should allow the unit to operate at such efficiency as to minimize the fuel requirement and the quantity of pollutants emitted.
5. Capital and operating costs should be minimized to the extent that other objectives are not compromised.

The existing Big Bend units utilize once-through cooling. Each of the three existing units rejects about 2 x 10^9 Btu/hr at full load. Water is drawn from the intake channel at the north side of the site (Figure 3-5) and pumped through the condensers. The water is discharged at the south side of the site into the discharge channel. Rated flow is 537 cfs per unit and the design temperature rise at full load is 16.8°F. There are two traveling screens (3/8-inch mesh) and two circulating-water pumps for each existing unit. Figure 3-6 shows the arrangement of the intake. There is a chain-link fence screen which extends 5 feet below the water surface to keep the intake area free of floating trash. Water passes into the traveling screen from two sides (Figure 3-6). It then enters the circulating-water pump, and from there goes to the condenser. The screens are rotated and backwashed once each shift, removing primarily jellyfish, crabs, leaves, and seagrass.

A system of dilution pumps, located on the discharge side of the plant, was once used in conjunction with the operation of the existing Big Bend units (Section 3.4.1.3). The plant now operates without thermal dilution flow.

3.4.1.2 Once-Through Cooling with Conventional Screens

With this alternative, which is similar to the existing system for Units 1-3, water is drawn from the inlet channel at the rate of 537 cfs. Water velocity approaching the screens is about 1.5 ft/s. The water passes through trash racks and conventional (coarse-mesh) traveling screens to the screenwell. From the screenwell it is pumped through the condenser and then flows to the discharge point south of the unit.

The discharge flow mixes with the discharges from the existing units before reentering Tampa Bay. The design temperature rise of the water passing through the Unit 4 condenser is 16.8°F at 100 percent load.

3.4.1.3 Once-Through Cooling with Dilution

This option is the same as the once-through alternative but with the addition of a flow of ambient unheated water into the discharge canal in order to reduce the temperature of the effluent before it enters Tampa Bay. A dilution system was used for a time at Big Bend in conjunction with the operation of Units 1, 2, and 3. This system could be activated for use with Units 1, 2, 3, and 4. The arrangement of the system is shown in Figure 3-7. There are two pumps in the existing arrangement, each with a capacity of 890 cfs. The intake to the pumps is provided with a trash rack to remove large debris. The low speed and large clearances within the pump allow fish to pass through with a minimum of injury. Water at ambient temperature is withdrawn by the pumps from the intake side of the site and released into the discharge stream. The resulting dilution lowers the temperature of the effluent. The temperature reduction is dependent on the volume of water passed through the dilution pumps.

A dilution system for Units 1, 2, 3, and 4 could use either one or two pumps. With all four units at full load, the dilution effect from one pump would reduce the temperature rise from intake to point of discharge from about 16.8°F to about 11.8°F. The reduction with two dilution pumps in operation would be to about 9.2°F. A system using two pumps would require some modifications to the existing arrangement at the site, including the possible addition of a third pump as a backup.

3.4.1.4 Cooling Towers with Saltwater Makeup

A consultant for the Applicant conducted a study to determine the preferred type of closed-cycle heat-rejection system for Big Bend Unit 4, based on an analysis of engineering, economic, and environmental considerations (Stone & Webster Engineering Corporation 1979). The closed-cycle systems considered in the study were a natural-draft cooling tower and a concrete circular mechanical-draft cooling tower with multiple fans.

The mechanical-draft cooling-tower system was selected primarily on the basis of economics. The net present value of the capital and performance costs associated with the natural-draft closed-cycle system was estimated to be approximately $22 million more than the mechanical-draft system. The net present value was computed by discounting annual capital and performance costs over an economic life of 28 years using a cost of capital of 8.62 percent. The higher net present value for the natural-draft system results from its significantly higher capital cost: the total capital cost of the system at the time of commercial operation, including escalation and interest during construction, is approximately $17 million more than the mechanical-draft system. Although there is a performance advantage for the natural-draft system of approximately $400,000 per year, this does not offset the high capital differential.

The Applicant believes that the natural-draft tower does not offer any significant environmental advantages that would outweigh its greater cost. The natural-draft tower was judged to be slightly preferable to the mechanical-draft tower in terms of salt-drift impacts, ground-fogging potential, and noise, but less desirable with respect to aesthetic impacts.

A closed-cycle system for Big Bend Unit 4 will be substantially more expensive than the proposed once-through system. In terms of capital cost, the mechanical-draft system represents an incremental cost of about $26 million at the commercial operation date. There is also a performance penalty of approximately $1.9 million per year. The net present value of the annual capital and performance costs of the mechanical-draft system is about $61 million more than the once-through system.

Figure 3-8 is a flow diagram showing the flow path of the condenser cooling water for this alternative. As described earlier in this section, water flows in a closed loop between the cooling tower and the condenser. As it passes through the condenser, it absorbs waste heat from the power-generating cycle. The heated water then flows to the top of the cooling tower and from there is sprayed down through the tower to a collection basin at the bottom. The water from the basin is then pumped back to the condenser, completing the circuit. Large fans at the top of the tower draw air through it and exhaust the air upward from the top. The water falling downward through the airstream is cooled by evaporation.

An important step in the design process is to find an optimum balance between the tower size and operating parameters on the one hand, and plant capability and efficiency on the other. This balance is affected by climatic conditions (primarily the temperature and moisture content of the air), and costs of construction and operation of the cooling tower and powerplant. Design data and optimized parameters for Big Bend Unit 4 are as follows:

Design wet-bulb temperature	81°F
Heat dissipation required	2.1 x 10^9 Btu/hr
Circulating-water flow	250,000 gallons per minute (gpm)
Evaporation	3,600 gpm
Water temperature to condenser	93°F
Water temperature from condenser	110°F

A cooling tower to serve Big Bend Unit 4 would have the shape of a portion of a cone. It would have a diameter of 81 meters (265 feet) at the bottom and 87 meters (285 feet) at the top deck. It would be 21 meters (70 feet) in height and have 13 fans, each of 175 horsepower. Because the tower cools by evaporating some of the water flowing through, water (called "makeup") must be added to replace it. Salt or minerals in the makeup tend to concentrate in the cooling tower water since the evaporation process removes only pure water, leaving other constituents behind. To control their concentration, a portion of the water circulating in the tower system is discharged as waste (called "blowdown") and the makeup is increased by a corresponding amount. In the case of the Big Bend Unit 4 tower, makeup (from Tampa Bay) would have an average salinity of 28 parts per thousand (ppt), and the design salinity in the water circulating in the tower would be 1.5 times that level, or 42 ppt. When operating at design capacity, the following flow rates are required:

Evaporation	3,600 gpm
Blowdown	7,100 gpm
Makeup	10,700 gpm

Makeup water would be taken through a makeup intake structure located either adjacent to the Unit 3 circulating-water intake or adjacent to the discharge canal. Blowdown would be discharged to the discharge canal.

During operation of the cooling tower, droplets of circulating water are entrained in the air flowing through the tower and are exhausted in the airstream leaving the top of the tower. These droplets, called "drift," contain the dissolved solids that are present in the circulating water--primarily salt in the case of Big Bend Unit 4. Drift eventually is deposited on soils, vegetation, structures, etc., with potentially harmful effects. In addition, cooling-tower drift may be considered to be an air pollutant subject to regulation. Cooling towers are equipped with drift eliminators, but, while they are capable of substantially reducing drift, they cannot eliminate it altogether. Cooling tower manufacturers are currently offering guarantees that the drift rates will not exceed 0.002 percent of the circulating-water flow.

It is probably technically feasible to reduce drift rates still further by using larger fill areas and larger and more elaborate drift eliminators, but only at the expense of increased fan power to move the air through the tower as well as increased tower size and cost.

3.4.1.5 Cooling Towers with Treated Wastewater Makeup

This alternative would be similar in concept to the alternative discussed in the paragraphs above, but some differences would emerge due to the differences in the makeup water. The reduced content of dissolved solids would allow for a considerably higher concentration factor (ratio of solids in the circulating water to solids in the makeup water) and higher drift rates. The circulating-water flow and heat dissipation rates would be unchanged from a tower system designed for saltwater makeup. However, the blowdown rate could be reduced by about one order of magnitude. Less elaborate and hence less costly drift eliminators would be required.

The makeup rate required would be about 4,300 gpm (about 6,200,000 gal/d) with the unit operating at maximum output.

As discussed in the section on alternative sites, treated wastewater is available in suitable quantities near certain alternative sites that were considered. However, there is no such supply within several miles of the Big Bend site. Thus, a large pipeline several miles in length would be required to transport the makeup water to the site. The cost of such a pipeline makes this system an expensive alternative.

3.4.1.6 Economic Analysis

The Applicant's analysis shows that the capital cost differentials (in millions of dollars) are as follows:

Once-through	Base
Once-through with fine-mesh screen on Units 3 and 4	8.7
Once-through with dilution	Base
Mechanical-draft cooling towers with salt water makeup	31.4
Mechanical-draft cooling towers with treated wastewater makeup	52.7

In addition, each alternative has various penalties associated with cooling system operation. These include the cost for reduction of the unit net generating capacity by the amount required for operation of the system (i.e., the capability cost), the cost of fuel required to generate power for system operation, the cost of labor, materials and supplies for operation and maintenance, etc. The capability and fuel costs for each of the alternative cooling systems are indicated in Table 3-10.

3.4.2 ALTERNATIVE ATMOSPHERIC POLLUTION CONTROL SYSTEMS

3.4.2.1 Sulfur Dioxide Control Alternatives

Sulfur dioxide (SO_2) emissions from Big Bend Unit 4 will be controlled by a combination of coal cleaning and a forced-oxidation, double-loop flue-gas-desulfurization (FGD) system. Alternative SO_2 control systems were evaluated according to their technical feasibility and ability to achieve a comparable or higher degree of emission control. Based on as-mined coal-sulfur content no greater than 12 lb $SO_2/10^6$ Btu and no less than 6 lb $SO_2/10^6$ Btu, 90 percent overall reduction in SO_2 emissions will be required of these processes in compliance with the revised new source performance standard (NSPS).

Various alternative SO_2 control techniques and systems are available. They may be categorized as follows: (1) coal pretreatment, (2) combustion techniques, and (3) post-combustion systems. These processes are in various stages of development and are commercially available for specific applications.

3.4.2.1.1 Coal Pretreatment

The alternative fuel-pretreatment techniques are chemical coal cleaning and solvent refining. Neither of these methods has been applied full-scale in the pretreatment of coal.

The former technique, chemical cleaning, generally uses the combination of pulverization followed by the addition of either an oxidation agent or a leachant. The sulfur compounds thus generated are removed by leaching or magnetic separation. Other chemical cleaning processes such as General Electric's (GE) microwave radiation/gasification process and Dynatech's microbial action process use more exotic techniques. These two processes are still in the early stages of development, and little information is available on their applicability and economic feasibility.

Table 3-11 summarizes the costs and effectiveness of physical coal cleaning versus chemical cleaning processes currently under development. Physical cleaning is not sufficiently effective in sulfur removal to serve as the principal means of SO_2 control. Since the chemical processes are neither economically competitive nor sufficiently demonstrated, they are not considered viable for application to the coal supply for Unit 4. (Data on the Dynatech and GE processes are insufficient to permit a detailed evaluation of them.)

The second fuel-pretreatment technique, that is, solvent-refined-coal (SRC) technologies, consists of dissolving pulverized raw coal in a coal-derived solvent in a hydrogen atmosphere at elevated temperature and pressure. To date, several demonstration plants have been operated in the United States; the economics and feasibility of these plants are still being evaluated. Consequently, SRC is not considered currently available for use by Big Bend Unit 4.

3.4.2.1.2 Combustion Techniques

The alternative to pulverized coal-firing for generation of steam is fluidized-bed combustion (FBC). FBC consists of burning coal in a bed containing both inert ash and an active sorbent that is used for SO_2 emission control. The bed is suspended by combustion air forced through the plate supporting the bed. The sorbent fed to the process, generally either dolomite or limestone, is calcined in the bed. Two types of FBC systems are currently under development: atmospheric FBC steam generation and the pressurized FBC combined-cycle process. Bench-scale models, pilot plants, and prototype units have been developed and evaluated by several manufacturers. Major problems yet to be resolved include hot-gas cleanup, materials of construction, and scale-up design data. FBC then is currently neither economical nor practical for application to full-scale electric-power generation and, therefore, is not considered a viable alternative for Big Bend Unit 4.

3.4.2.1.3 Postcombustion Systems

Alternative postcombustion SO_2 control systems include numerous FGD processes, both nonregenerable and regenerable, using various absorber designs, reaction-chemistry, and reagents. However, the FGD systems considered currently available and capable of the SO_2 removal efficiencies required by the NSPS are limited to the following:

1. Nonregenerable:
   a. Lime/limestone slurry scrubbing
   b. Dual alkali utilizing sodium carbonate
2. Regenerable:
   a. Magnesium oxide
   b. Sodium carbonate (Wellman-Lord)

Sufficient operational experience has been obtained on coal-fired boilers (pilot plants, prototypes, and commercial units) to permit an evaluation of the costs, performance, and reliability of each of these FGD systems.

The factors considered in the selection of the limestone FGD system for control of SO_2 emissions from Unit 4 include water consumption, energy penalty, capital and operating costs, availability, and performance.

The water requirements and energy penalties for the available nonregenerable FGD systems are similar and are significantly lower than those of regenerable systems. The higher consumption of the regenerable systems results primarily from additional requirements for operation of the sulfur-recovery systems. Table 3-12 presents the water and energy requirements for these alternative systems in terms of a generic 425-megawatt unit.

The capital cost and annual operating and maintenance (O&M) cost for each of the alternative processes vary significantly depending on specific user requirements and coal characteristics. Generally, the capital cost for regenerable processes is considerably higher than that for nonregenerable processes because of the need for use of sulfur-recovery systems. O&M costs are similar for all five processes if the FGD sludge from the nonregenerable systems is to be stabilized and disposed of by landfill. The disposal costs are highly labor-intensive and are sensitive to the proximity of the landfill site to the source. However, if the FGD system produces a gypsum material that is marketed, the O&M costs favor such a nonregenerable system. Table 3-13 summarizes the unit capital and annual costs in 1980 dollars for each of the five FGD systems as applied to a generic 425-megawatt unit. The SO_2 removal efficiency of the systems is assumed to be 90 percent. These costs are based on the assumptions that gypsum is produced and marketed and that the credit received is sufficient to cover its transport costs. The other economic factors and unit costs used to derive O&M costs are also presented in this table. Operational experience indicates that the performance and availability of each FGD system are similar.

The FGD system proposed for control of SO_2 emissions from Big Bend Unit 4 is a modification of the wet-scrubbing, limestone-reagent throwaway process illustrated in Figure 3-9. This system will be adapted for production of a salable gypsum product. The reagent used in the selected system will be limestone, which is readily available from the Florida region directly north of Tampa and is inexpensive in the Tampa area.

The magnesia (MgO) process involves use of MgO to absorb SO_2 in a wet scrubber and the subsequent regeneration of the MgO for production of commercial sulfuric acid. This process is presently undergoing continued testing, modification, and demonstration at utility plants. Considerable emission and dust-emission problems have been encountered. The demonstration plants have shown 90 percent SO_2 recovery. However, due to low system availability and high capital and operating costs, the system was not considered a viable alternative for Big Bend Unit 4.

The alternative FGD systems considered were the dual-alkali system, the lime system, and the Wellman-Lord regenerable process.

The dual-alkali FGD system uses two alkalies: sodium-base liquor in the scrubbing section, and lime in the sodium-sulfite-regeneration section (Figure 3-10). There are several features of this system that make it economically unattractive for this site. The two alkalies used in this process are expensive and not readily available. While absolute quantities of the reagents used are less for the double-alkali system than for to the limestone system, the overall cost of reagent for the double-alkali system is very much greater. At the same time, the capital and O&M costs of the two systems are not significantly different. In addition, the waste solids produced by this process have a high proportion of calcium sulfite ($CaSO_3 \cdot 1/2H_2O$) and significant quantities of highly soluble sodium salts in their surface moisture. This waste would probably require stabilization to prevent leaching of the salts at the disposal site and to prevent the calcium sulfite from exerting a chemical oxygen demand. Such developments would significantly increase the disposal costs.

The lime FGD system uses lime as its reagent (Figure 3-11) and is very similar to the limestone FGD system. Although a generic comparison of these two processes, as presented in Table 3-13, indicates a small cost advantage for lime FGD, limestone FGD is expected to be less costly for the Big Bend Unit 4 site. There are several features of the lime system (similar to the dual-alkali system) which make it economically unattractive for this site when contrasted with limestone usage.

First is the higher cost and limited availability of the required lime reagent. This would approximately quadruple the reagent operating cost for this system over a limestone process while the capital equipment and other O&M costs of the two systems would remain approximately equal. Second, the waste produced would be nearly all calcium sulfite ($CaSO_3 \cdot 1/2H_2O$), which has a chemical oxygen demand and is highly thixotropic. This would require that it be stabilized before it could be landfilled in accordance with the Resource Construction and Recovery Act of 1976 (RCRA) and would considerably increase waste-disposal costs.

The last alternative is the Wellman-Lord process (Figure 3-12). This is a regenerable process that produces a marketable end product, either elemental sulfur or sulfuric acid. In the Tampa area, sulfuric acid would be the more desirable product, for there are several industries which use sulfuric acid. This system uses soda ash as its reagent supply and has removal efficiencies similar to the double-alkali FGD system. A demonstration plant at a utility in Gary, Indiana, is reported to have an SO_2 design removal efficiency of 90 percent. Since this system produces a marketable end product, waste disposal is minimized. Nevertheless, there are several features of this system which make it economically unattractive. The first is its energy-intensiveness, which exacts a severe economic penalty. As can be seen from

Tables 3-12 and 3-13, the Wellman-Lord process requires higher capital and operating costs and has higher water requirements and energy penalties. The second is the high cost and limited availability of soda ash. Because of the very low reagent consumption of the system, however, this is not a very significant disadvantage. Third, a complete sulfuric acid production plant and a tank-farm facility are required to permit production of this marketable by-product. This would require additional capital and add to operating and maintenance costs. Finally, the utility must enter into sulfuric acid sales, a market with which it is completely unfamiliar. Preliminary inquiries have revealed little interest in the purchase of such sulfuric acid. W. R. Grace Company, Allied Chemical Company, Swift Agricultural Chemicals Corporation, Ashland Chemical Company, and Canadian Industries Limited were contacted. All indicated that they were not interested in the outright purchase of the sulfuric acid. However, they were interested in becoming marketing agents.

The Wellman-Lord system would incorporate a 60-day tank-farm storage system. Any filling-up of this tank farm owing to a lack of acid shipments would inhibit the use of the scrubber. Thus, the operation of the scrubber would become strongly dependent upon the utility's ability to sell the sulfuric acid.

Because of economic and energy penalties associated with the alternative systems and due to its presumed cost-effectiveness in achieving the NSPS SO_2 emission limit, the limestone FGD system was selected for SO_2 removal at Big Bend Unit 4.

3.4.2.2 Particulate Control Alternatives

There are four major methods generally available for control of particulate matter (PM):

1. Wet scrubber (venturi type)
2. Fabric filter (baghouse)
3. Mechanical collector (cyclone)
4. Electrostatic precipitator (ESP)

The particulate-collection equipment proposed for Big Bend Station Unit 4 is a rigid-frame ESP. This ESP will be of the 99.5+ percent removal efficiency class based upon the burning of medium- or high-sulfur coal. It will be designed to meet the revised NSPS emission limit of 0.03 lb/10^6 Btu and 20 percent opacity. It will also have provisions to later incorporate future technological advances to meet the NSPS requirements in the event of the firing of low-sulfur coal as boiler fuel. The rigid frame design was selected to provide added reliability over the weighted-wire design frequency used for the high-voltage electrodes. A redundant electrical field is also added to increase its reliability.

Wet scrubbers for particulate collection not only use excessive energy but also produce waste ash slurry, thereby creating equipment erosion and disposal problems. Mechanical collectors have low efficiency and high operating cost, and at the same time they require back-up by an ESP to achieve emission control compliance. Because of the major shortcomings of these two methods, they are not considered as possible alternative particulate removal systems for Big Bend Unit 4.

The only alternative to electrostatic precipitation that was investigated was fabric-filter-type particulate-collection equipment. This type of equipment is the only alternative considered technically feasible for adequately limiting emissions from

Big Bend Unit 4. It has been commercially demonstrated on both utility and industrial boilers and has achieved emission reductions substantially greater than 99 percent.

The U.S. Environmental Protection Agency (EPA) considers fabric-filter installations to be available for control of PM in the utility industry. The baghouse test data cited by the EPA in support of this contention have been gathered from relatively small units, only two of which are utility boilers, and only one of these fires pulverized coal. These data are summarized in Table 3-14. The EPA believes that by using modular design techniques a design base now exists for scaling up existing, proven designs applicable only to relatively small units. To defend this position, the EPA notes that about 50 baghouse-equipped, coal-fired utility steam generators are scheduled to begin operating in the near future (before 1983). These baghouse facilities will be used for many units larger than 150 megawatts and for both high- and low-sulfur coal.

On the other hand, the utility industry believes that baghouses are not demonstrated technology for large coal-fired units, particularly those firing higher sulfur coals. No long-term data exist on bag life at large coal-fired electric-power-generating facilities or on the specific relationship between service life and sulfuric acid dewpoint temperature. Potential problems of concern to industry include interstitial plugging caused by condensation or products of incomplete combustion (particularly during periods of boiler startup and cycling). Moreover, uncertainties relative to design (e.g., the design of compartment seals and dampers), heaters and insulation, startup procedures, and reverse-air fan-capacity requirements have yet to be resolved. In short, the utility industry believes that experiential knowledge concerning the operation of small boilers cannot necessarily be extrapolated to the operation of much larger units firing coals with widely varying characteristics.

To meet the NSPS for particulate emissions, the Unit 4 steam generator will use an ESP rather than a fabric-filter installation. The selection is primarily based on the demonstrated availability and reliability of the ESP on similar facilities firing high-sulfur coals. In addition, ESPs and baghouses are considered to be capable of comparable particulate collection efficiencies for boilers firing those coals under consideration for Unit 4. Generally, the fabric filter is capable of providing slightly higher removal efficiencies. However, the cost-effectiveness of the ESP versus the fabric filter is dependent upon the sulfur content of the fuel being used. In a low-sulfur application, the fabric filter would usually be more cost-effective in achieving high removal efficiencies; the ESP required to approximate the same efficiency would be very large due to the increased electrical resistivity of the ash. This does not hold true for a medium- to high-sulfur case such as Big Bend Unit 4. Here, the reduced electrical resistivity of the ash permits use of a much smaller ESP that approximates fabric-filter efficiency. Thus, the ESP becomes much more cost-effective than the fabric filter for this application. Additionally, the fabric-filter collection equipment would operate with a higher energy loss due to gas-pressure drop, and its O&M costs would be significantly higher for this application.

Indeed, the EPA recognizes in their BACT guidelines that ESPs and baghouses have similar control capabilities. The incorporation of the ESP in the design of the steam-generation system is thus judged BACT for PM emissions from Unit 4, and no alternative control system capable of a higher degree of emission reduction is currently available for that unit.

As in the case of fly ash from existing Big Bend units, fly ash collected in Unit 4 will be marketed by TECO to various users. Provisions for fly-ash stabilization will be made so that the ash can be disposed of in accordance with RCRA should the market for the ash at some future date cease to exist and alternative methods for its disposal become necessary.

3.4.2.3 Oxides of Nitrogen

Generally, required reductions in nitrogen oxide (NO_x) emissions are possible through alternative combustion techniques. These include:

1. Water or steam injection
2. Flue-gas recirculation
3. Over-fire air, also known as two-stage combustion

The applicability of these techniques may vary for different boiler manufacturers. The boiler manufacturer selected for the plant may be expected to implement one or more of the above techniques as applicable and required for controlling NO_x emissions.

The proposed combustion-type control technology for NO_x emissions from the Unit 4 steam generator is considered the only available system capable of meeting the NSPS. The NSPS for NO_x emissions was based on the application of combustion modifications either in the boiler furnace or combustion-air-control system. The only way to further reduce NO_x emissions is to use tail-gas treatment, including wet (oxidation or chemical reduction in conjunction with scrubbing) and dry (chemical-reduction) methods. These processes, however, are still in the early stages of development. The major work on flue-gas treatment has been conducted in Japan, and, as yet, this treatment is commercially available only for oil- and gas-fired facilities. In the United States, the EPA is sponsoring programs for investigation of this type of flue-gas treatment, but no demonstration plant has yet gone into operation. The use of off-stoichiometric combustion is thus judged BACT for control of NO_x emissions, and no alternative control system with a higher degree of emission reduction is currently available.

3.4.2.4 Carbon Monoxide

Carbon monoxide emissions from the Unit 4 boiler will be minimized by operation at excess-air levels sufficient to achieve essentially complete combustion to carbon dioxide and by appropriate design of the combustion-air-control system. This system is judged BACT for the control of CO, because no alternative means of controlling this pollutant is currently available or under development.

3.4.2.5 Summary

The general alternative designs for the control of SO_2, particulate matter, and NO_x emissions and the advantages and disadvantages of these designs are summarized in Table 3-15. Among these, only those viable for Big Bend Unit 4 are addressed in detail in the foregoing text.

The selected systems for the control of SO_2 and particulates are limestone FGD (augmented by coal washing) and electrostatic precipitation, respectively. These systems are addressed in detail in Sections 4.2.5.4. The systems included in the design and operational procedures for the control of PM, NO_x, and CO emissions are considered BACT, because no alternative systems capable of a higher percentage reduction in potential emissions are currently available. For SO_2 emissions, fuel pretreatment and an FGD system with a combined percentage reduction in potential SO_2 emissions of 90 percent is proposed as BACT for the Unit 4 steam generator.

3.4.3 ALTERNATIVE PLANT WATER AND WASTEWATER SYSTEMS

3.4.3.1 Alternative Makeup Water Sources

Possible makeup water sources for the alternative closed-cycle heat dissipation system are Hillsborough Bay, freshwater, and brackish ground water, as discussed below.

3.4.3.1.1 Hillsborough Bay

Hillsborough Bay, the source of once-through cooling water for Big Bend Units 1, 2, and 3, is the source for the proposed Unit 4 once-through-cooling system. The bay is also considered the primary candidate as the source of makeup water for a closed-cycle cooling system. A description of the physical and chemical characteristics of Hillsborough Bay is provided in Section 2.3.3.

3.4.3.1.2 Freshwater

The freshwater resources in the Big Bend area are limited to ground water that is utilized for agricultural activities. Diversion of the quantities of water needed to supply a closed-cycle system would place a great burden on the local ground-water resources. For this reason, investigative efforts have concentrated on finding a feasible source of sewage treatment plant effluent. The use of treated sewage effluent from municipal systems remains a very promising alternative in that the quality of water is compatible with its intended use.

3.4.3.1.3 Brackish Ground-Water Supply

An investigation is being performed to evaluate brackish artesian water as an alternative source of station makeup water. Approximately 5,000 to 7,000 gal/min or makeup water at less than 20,000 ppm dissolved solids and with temperatures less than 90°F would be required. Additional investigations would be required to determine whether or not the withdrawal of brackish water from the deep artesian aquifers would be detrimental to the environment, particularly with respect to the existing quality and potentiometric surface of freshwater stored in the shallower artesian aquifers. These shallower aquifers have been used extensively for land irrigation as well as for industrial, commercial, and domestic water supply over a broad area adjacent to the plant site.

Preliminary indications are that brackish makeup water which meets and exceeds quality, quantity, and environmental requirements can probably be supplied from an approximate depth of 2,000 to 3,000 feet.

If the need for a brackish-water cooling-tower makeup source becomes a reality, additional studies will be required. This would include hydraulic modeling and a field-testing program.

3.4.3.2 Alternative Wastewater Systems

Two alternative methods of treating the FGD system chloride bleed stream, boiler blowdown, and bottom-ash blowdown to meet water-quality criteria before mixing have been evaluated by the Applicant: the use of reverse osmosis and the treatment of the boiler and bottom-ash blowdowns in the treatment system provided for the FGD chloride bleed stream.

Reverse Osmosis

TECO's analysis indicates that it would not be practicable to use reverse osmosis to treat the indicated waste streams. The boiler and bottom-ash blowdown streams are projected to have total-dissolved-solids concentrations at or below 500 parts per million. These concentrations are considered to be below acceptable levels for the optimum operation of a reverse-osmosis system. In the FGD chloride bleed stream, the total-dissolved-solids concentration is projected to be approximately 108,000 parts per million. The treatment of such a concentration would require reverse-osmosis membranes capable of withstanding pressures of more than 2,000 pounds per square inch, which is beyond the capability of standard reverse-osmosis systems. Moreover, the chemical constituents of the FGD bleed stream could cause scaling of the membrane.

The Applicant also states that reverse-osmosis treatment would not produce a measurable improvement in the water quality of the effluent at the point of discharge. Accordingly, TECO believes that the estimated $1.8 million cost of the system would not be justified, since no detectable benefit in water quality would result.

Use of the FGD-Bleed-Stream-Treatment System

The system for treatment of the FGD bleed stream is designed for the removal of suspended solids and for the adjustment of pH to meet effluent standards. This system would have to be upgraded to handle the flows from all three blowdown streams. The cost for redesigning the system is estimated by TECO at about $1.2 million.

The Applicant states that treatment of the boiler and bottom-ash blowdowns in the system for treatment of the FGD bleed stream is not practicable for the following reasons:

1. Boiler blowdown will be very low in suspended solids (4 milligrams per liter) and will have a pH in the range of 8.5 to 9.0. These values are in compliance with effluent limitations.

2. Bottom-ash transport slurry will be treated by ponding to remove suspended solids. The ponds have been designed to achieve a suspended-solids-removal efficiency that will allow the blowdown to meet effluent limitations, and the pH of the bottom ash will comply with effluent limitations without treatment.

3.4.4 ALTERNATIVE SOLID-WASTE-DISPOSAL SCHEMES

3.4.4.1 Introduction

Two major kinds of solid wastes will be produced in the operation of Big Bend Unit 4. These principal wastes include ash from coal combustion in the form of bottom ash and fly ash, and the product of the SO_2 absorption reaction in the operation of the flue-gas-desulfurization (FGD) system. The FGD system design selected will yield high-grade calcium sulfate solids. Minor solid wastes are anticipated due to pyrites rejection from coal-pulverizer mills and sludge formation in wastewater treatment.

3.4.4.1.1 Solid-Waste Transport

The solid wastes resulting from the operation of Big Bend Unit 4 include bottom ash, economizer ash, pyrites, fly ash, and FGD solids. Bottom ash will be collected and sluiced to ash ponds for settling and disposal. Marketable fly ash will be removed from the flue gas by an electrostatic precipitator and sold (as the market allows) for use as a raw material in the production of portland cement. Unmarketable fly ash, pyrites removed from the coal prior to combustion, and economizer ash will be collected and sluiced to ash-settling ponds (separate from the bottom ash ponds) for settling and disposal. The FGD system utilizes an adaptation of limestone wet scrubbing to produce by-product calcium sulfate (gypsum), which is expected to be sold for use as a raw material in gypsum wallboard manufacture. A detailed description of the proposed solid-waste-management scheme is presented in Section 4.2.6.

3.4.4.1.2 Solid-Waste Production

Ash and FGD by-product gypsum represent the major portion of solid-waste production at Big Bend Unit 4. The rate of production will depend upon the characteristics of the coal burned and the capacity-factor/coal-firing rate of the plant. Based on anticipated long-term operation, the annual production of bottom ash, fly ash, FGD by-product (gypsum), and pyrites are expected to average 25,680, 102,400, 240,000, and 19,000 tons, respectively.

3.4.4.1.3 Selected Solid-Waste-Disposal Scheme

The bottom ash will be collected in a water-filled hopper and hydraulically sluiced to settling ponds, the clarified water removed, and the ash solids hydraulically dredged to a final disposal cell. Fly ash to be marketed will be collected and pheumatically transported to silos for storage and for subsequent sale. Unmarketable fly ash, pyrites, and economizer ash will be sluiced to settling ponds, the clarified water removed, and the ash and pyrite solids hydraulically dredged to a final, lined disposal cell. The by-product gypsum is to be stored on the site in an area south of the Unit 4 ash pond. The full description of the selected solid-waste-disposal scheme is presented in Section 4.2.6.

3.4.4.2 Alternative Waste-Management Schemes

Available disposal schemes other than that selected for Big Bend Unit 4 include offsite disposal and commercial utilization without throwaway disposal.

3.4.4.2.1 Offsite Disposal

In offsite disposal of ash and scrubber sludge, hauling and handling operations would entail transferring these wastes to such remote sites as a coal mine, limestone quarry, phosphate mine, an impoundment, or a landfill. The cost of long-distance transport is a major deterrent to offsite disposal. At the same time, the strong prospect for sale of major amounts of the wastes to markets with time-varying demands calls for retaining the salable materials onsite until needed by purchaser(s).

3.4.4.2.2 Commercial Utilization Without Throwaway-Waste Disposal

The fly ash is expected to be used for cement production and the by-product gypsum is expected to meet a local market for gypsum wallboard manufacture. Thus, these two products have great potential for commercial utilization, and simultaneous provision for solid-waste management through throwaway disposal may be judged inappropriate. There is, however, significant uncertainty as to the stability of the local Florida market for these materials. Thus, this alternative disposal scheme, devoid of provisions for land-based storage/disposal, is not considered adequate for plant-design planning or long-range plant operation.

3.4.4.3 Evaluation of Alternative Disposal Schemes

Each of the alternative solid-waste-disposal schemes outlined above has major disadvantages, and neither constitutes a viable alternative to the solid-waste-disposal scheme selected for Big Bend Unit 4. Thus, detailed analysis of these alternatives has not been considered appropriate.

3.4.4.4 Summary

Although alternative methods of solid-waste management are theoretically available, the major shortcomings of each of these methods make them unacceptable. Therefore, provision for long-term onsite storage/disposal of a commercial-grade, potentially marketable gypsum and of normally marketable fly ash by-product, as described in Section 4.2.5, is considered to be the best scheme for by-product management of the principal solid wastes at Big Bend Unit 4.

3.4.5 ALTERNATIVE TRANSMISSION SYSTEMS

As discussed in Section 4.2.9, the transmission line to be constructed for Big Bend Unit 4 consists of one circuit (three conductors) that will parallel the existing transmission circuits associated with Units 1, 2, and 3. An existing right-of-way and existing towers will be used for the new line, which will be 2,970 feet (9/16 mile) in length. Alternative routing would require construction of new towers and creation of a new right-of-way. Such an approach would be undesirable on both aesthetic and economic grounds. Accordingly, no detailed consideration has been given to alternative transmission systems.

Table 3-10. Major cost penalties associated with operation of alternative waste-heat-rejection systems

System	Capability cost ($)	Fuel cost ($/yr)
Once-through	Base	Base
Once-through with fine-mesh screen on Units 3 and 4	106,000	69,000
Once-through with dilution	168,000	86,000
Mechanical-draft cooling towers with saltwater makeup	6,324,000	2,149,000
Mechanical-draft cooling towers with treated wastewater makeup	6,660,000	2,321,000

Table 3-11. Costs and effectiveness of coal-pretreatment processes of physical versus chemical cleaning

	Product coal				Costs		
	Plant size	Btu recovery	Sulfur removal (%)		Capital	Processing	
Process	(ton/hr)	(%)	Pyritic	Organic	(10^6)	$/ton	$/10^6$ Btu
Physical	500	80-95	35-70	--	9.0	4.27	0.18
TRW/Meyers	380	90	95	--	145	10-14	0.82
Battelle	400	75-90	99	24-72	134-145	18-25	1.00
Hazen	330	76	80	--	48	14.00	0.60
KVB	330	90	99	13	68	23.00	0.98
Ledgemont (LOL)	330	93	95	--	150	19.00	0.81
Bureau of Mines/ ERDA	330	94	95	15	130	19.00	0.84
Dynatech	330	NA	NA	NA	NA	4.05	NA
GE	400	NA	50 combined		NA	6.60	NA

Abbreviation: NA = not available.

Table 3-12. Utility and energy penalties for alternative FGD systems[a]

	Water requirements		Energy penalty	
FGD system	gpm	Percentage of plant total	Btu/(kW)(hr)	Percentage of plant output
Nonregenerable				
Limestone	540	8.2	307	3.4
Lime	540	8.2	273	3.0
Dual-alkali	590	8.8	273	3.0
Regenerable				
MgO (Chemico)	670	9.9	478	5.3
Na_2CO_3 (Wellman-Lord)	760	11.2	1,060	11.7

Abbreviation: gpm = gallons per minute.

[a] From U.S. Environmental Protection Agency (1978).

Table 3-13. Capital and annual costs (1980 dollars) for alternative FGD systems

FGD system	Capital cost ($/kW)	Annual costs (mills/(kW)(hr) O&M	Fixed charges	Total
Nonregenerable				
Limestone	145.20	3.4	5.8	9.2
Lime	124.50	3.7	5.0	8.7
Double-alkali	163.80	4.2	6.5	12.2
Regenerable				
MgO (Chemico)	174.60	5.6	7.0	12.6
Na_2CO_3 (Wellman-Lord)	154.90	4.5	6.2	10.7

Abbreviations:

FGD = flue-gas desulfurization.

O&M = operation and maintenance.

[a] Capital cost of sludge treatment, if required, would be approximately $15/kW and O&M costs would be 1.5 mills/(kW)(hr).

Note: Economic factors

Raw materials cost ($/ton)	
Limestone	9.10
Lime	40.20
Soda ash	105.00
MgO	185.00
Fuel oil	15.00
Credits ($/ton)	
Sulfuric acid	25.00
Salt cake	50.00
Gypsum	0
Electricity	25 mill/kW-hr
Capital recovery	18.5% capital cost
Taxes/insurance	4.0% capital cost

Table 3-14. Emission test results for fabric-filter systems on coal-fired steam generators

Company	Plant	Type	Coal MW	Coal Type	Percent sulfur	PM emission ($lb/10^6$ Btu)
Pennsylvania Power and Light	Sunbury	U	44	PC	2.0	0.0028-0.01
Colorado Ute Electric Association	Nucla	U	13	SS	0.7	0.0014-0.018
Adolph Coors		I	25	PC	0.5	0.032-0.043
Caterpillar Tractor		I	10	SS	2.0	0.008-0.012
Unnamed		I	18	SS	NA	0.026
Unnamed		I	12.5	SS	NA	0.009
Unnamed		I	24	SS	NA	0.042
Unnamed		I	6.4	SS	NA	0.015

Abbreviations:

PM = particulate matter.
U = utility boiler.
I = industrial boiler.
PC = pulverized coal.
SS = spreader/stoker.
NA = not available.

Table 3-15. Atmospheric pollution control systems (Sheet 1 of 4)

System	Advantages	Disadvantages
SO_2 control		
Coal beneficiation (mechanical washing, magnetic separation, and chemical separation)	Reduces amount of waste resulting from the flue-gas-cleaning process	Mechanical washing depends on availability of water near mine Magnetic and chemical separation are still in laboratory testing stage Beneficiation of coal would not allow applicable emission standards to be met without use of other control methods
Solvent-refined coal	Low in ash and sulfur	Still in developmental stage Very costly; product is not available in required quantities
Flue-gas desulfurization (FGD)		
Wet lime or limestone scrubbing	Can remove up to 90 percent of sulfur from flue gases Least expensive and most common of FGD processes now in operation	As typically applied in U.S., it results in a waste product of precipitated calcium sulfite/calcium sulfate, which requires a large land area for disposal Potential ground-water problems associated with waste disposal Potential for some scaling or plugging of scrubber system
Dual-alkali scrubbing	Reduces scrubber scaling and plugging problems Has been used successfully for utility and industrial boilers	Waste product contains sodium salts with potential for water pollution Loss of principal reactant (sodium salts) in waste makes the process more expensive in chemical usage than lime/limestone scrubbing

Table 3-15. Atmospheric pollution control systems (Sheet 2 of 4)

System	Advantages	Disadvantages
	SO$_2$ control (continued)	
Flue-gas desulfurization (FGD) (continued) Double-alkali scrubbing (continued)		Results in a waste product of precipitated calcium sulfite/calcium sulfate, which requires a large land area for disposal Potential ground-water problems associated with waste disposal
Magnesium oxide scrubbing	Process produces small amounts of waste, recycles regenerated alkali material for use as reactant, and yields potentially marketable by-product Suitable for areas with limited sludge disposal space and a potential market for the sulfur by-product If added cost can be defrayed by assumed chemical sales revenue, may prove to be less expensive scrubbing method over life of plant	Presently more expensive on a first-cost and operating-cost basis than previous two methods Mechanical engineering problems in thermal regeneration of MgO May entail problems in marketing the by-product because of the large quantities produced Process presently is still undergoing testing and development on large-scale demonstration units
Catalytic oxidation (Monsanto Cat-Ox)	Process produces small amounts of waste, recycles material used as reactant, and yields potentially marketable by-product If added cost can be defrayed by assumed sales revenue, could prove to be less expensive scrubbing method over life of plant	Difficulty in producing high temperatures for the dry process Corrosion and cooler plugging in acid section of system Contamination by fly ash may adversely affect the life of the catalyst Capital and operating cost higher than for lime/limestone scrubbing

Table 3-15. Atmospheric pollution control systems (Sheet 3 of 4)

System	Advantages	Disadvantages
	SO$_2$ control (continued)	
Flue-gas desulfurization (FGD) (continued) Catalytic oxidation (Monsanto Cat-Ox) (continued)		Additional marketing problems associated with reduced-strength sulfuric acid by-product Process appears to have failed in demonstration-plant stage
Sodium alkali scrubbing	Process produces small amounts of solid wastes, recycles materials used as reactant and yields by-product Has been installed and operated full-scale at several coal-fired facilities Minimum capital cost with no use of solid-dewatering equipment	Lifetime operating costs are higher than for lime/limestone scrubbing
	Primary control of particulates	
Electrostatic precipitator	Removal of fly ash up to approximately 99.6 percent efficiency, commonly utilized and reliable, low operating and maintenance costs	
Wet scrubber - Venturi type		Excessive energy (gas pressure drop) consumption, large volumes of acidic water, produces waste sludge and associated disposal problems
Fabric filter (baghouse)		Larger space requirements, limited design temperatures, and higher maintenance costs and gas pressure drop

Table 3-15. Atmospheric pollution control systems (Sheet 4 of 4)

System	Advantages	Disadvantages
Primary control of particulates (continued)		
Mechanical collectors (cyclone)		Low removal efficiency, necessitating the supplemental use of one of the above high-efficiency devices, hence high capital and operating costs
NO_x control		
Water injection		High loss in thermal efficiency makes this method expensive in times of rising fuel costs and scarcity of energy resources
Flue-gas recirculation	Easily adapted to coal firing Produces lowest NO_x levels Easier to control than over-fire air	Much higher capital cost
Over-fire air	Like flue-gas recirculation, has been used extensively to control steam temperature NO_x are reduced with relatively little capital cost	

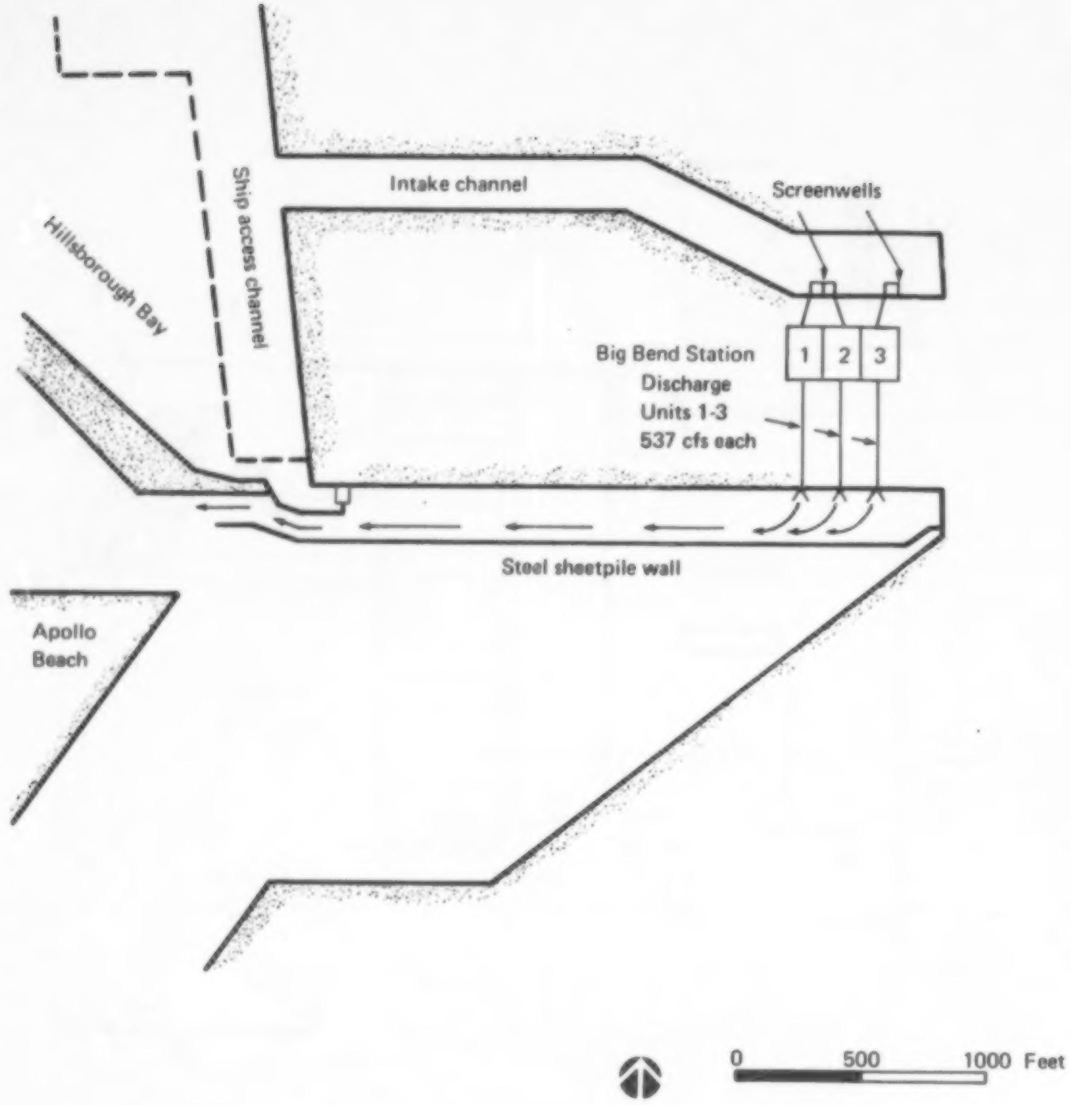

Intake channel
Screenwells
Ship access channel
Hillsborough Bay
Big Bend Station
1
2
3
Discharge
Units 1-3
537 cfs each
Steel sheetpile wall
Apollo Beach
0
500
1000 Feet

Figure 3-5. Once-through-condenser cooling system, Units 1-3 at Big Bend Station.

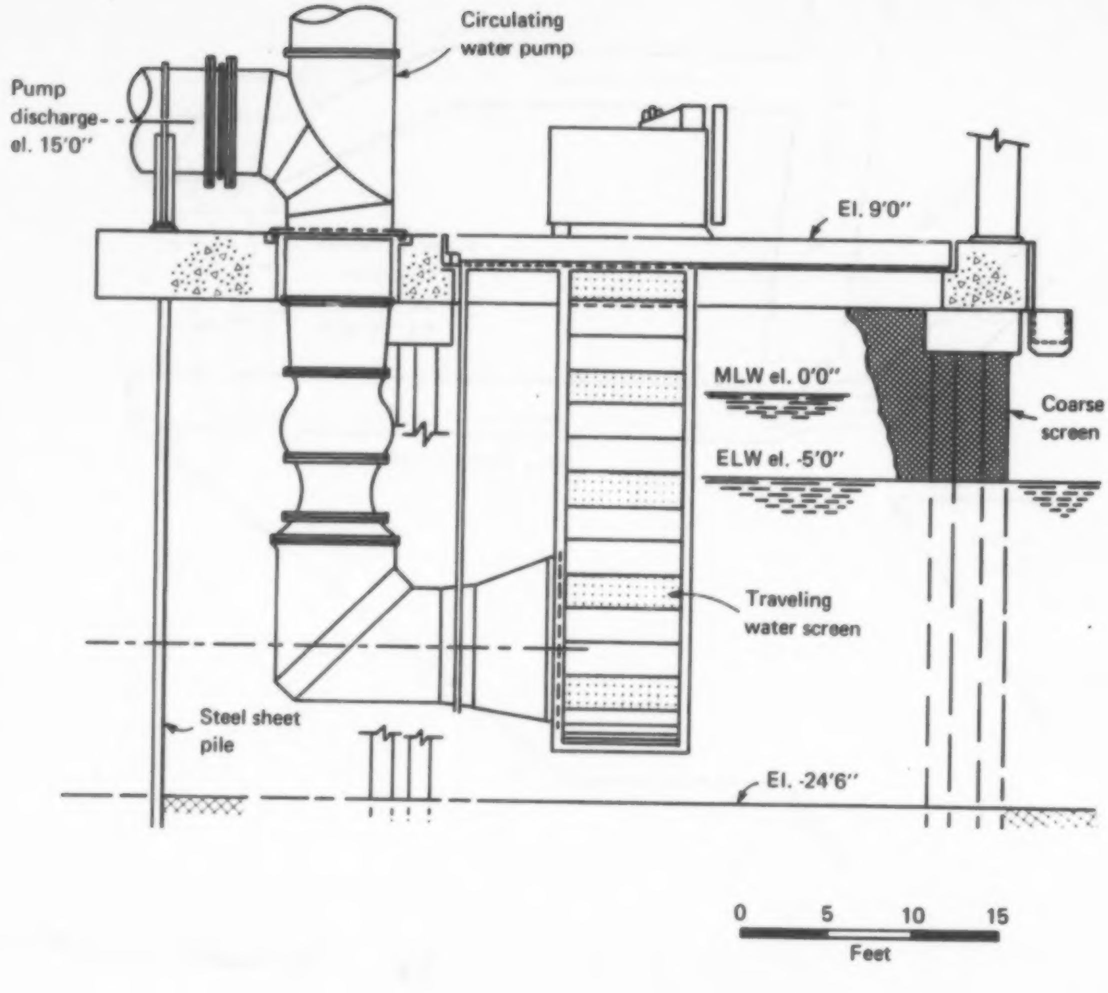

Circulating water pump
Pump discharge el. 15'0"
El. 9'0"
MLW el. 0'0"
ELW el. -5'0"
Coarse screen
Traveling water screen
Steel sheet pile
El. -24'6"
0
5
10
15
Feet

Figure 3-6. Existing screenwell arrangement for circulating-water-intake system at Big Bend Station Units 1-3.

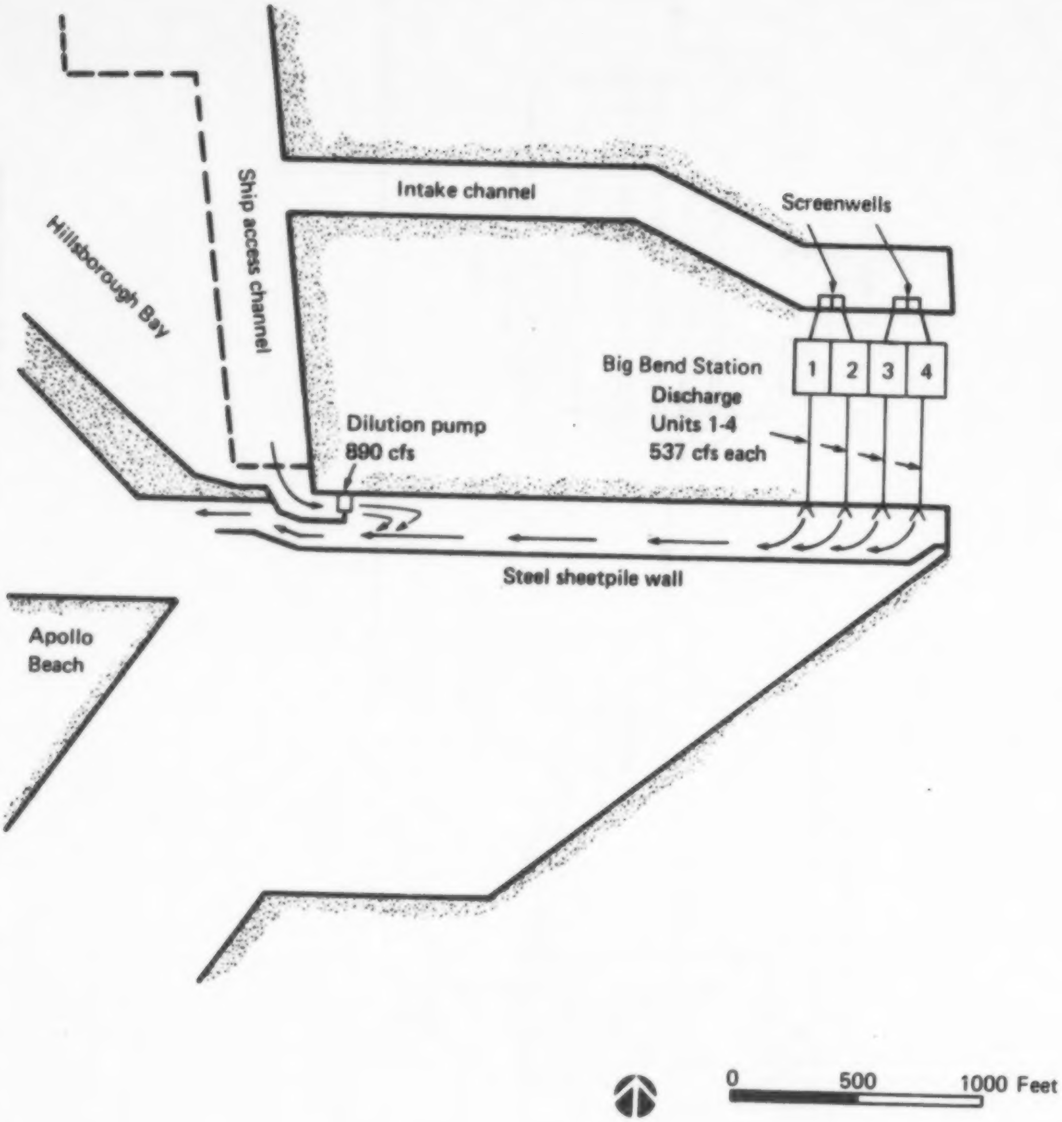

Intake channel
Screenwells
Ship access channel
Hillsborough Bay
Big Bend Station
1
2
3
4
Discharge
Units 1-4
537 cfs each
Dilution pump
890 cfs
Steel sheetpile wall
Apollo
Beach
0
500
1000 Feet

Figure 3-7. Once-through-with-dilution cooling system, Units 1-4 at Big Bend Station.

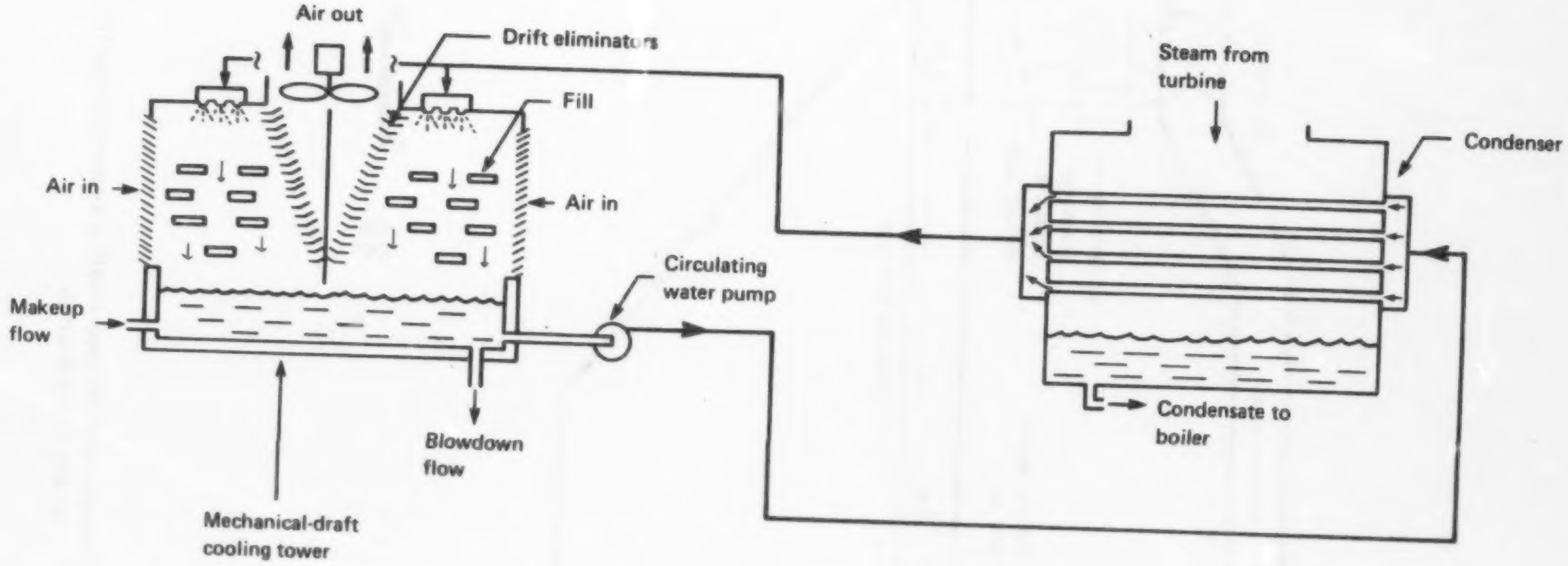

Air out
Drift eliminators
Fill
Air in
Air in
Makeup flow
Circulating water pump
Blowdown flow
Mechanical-draft cooling tower
Steam from turbine
Condenser
Condensate to boiler

Figure 3-8. Condenser cooling water flow path with mechanical-draft cooling tower.

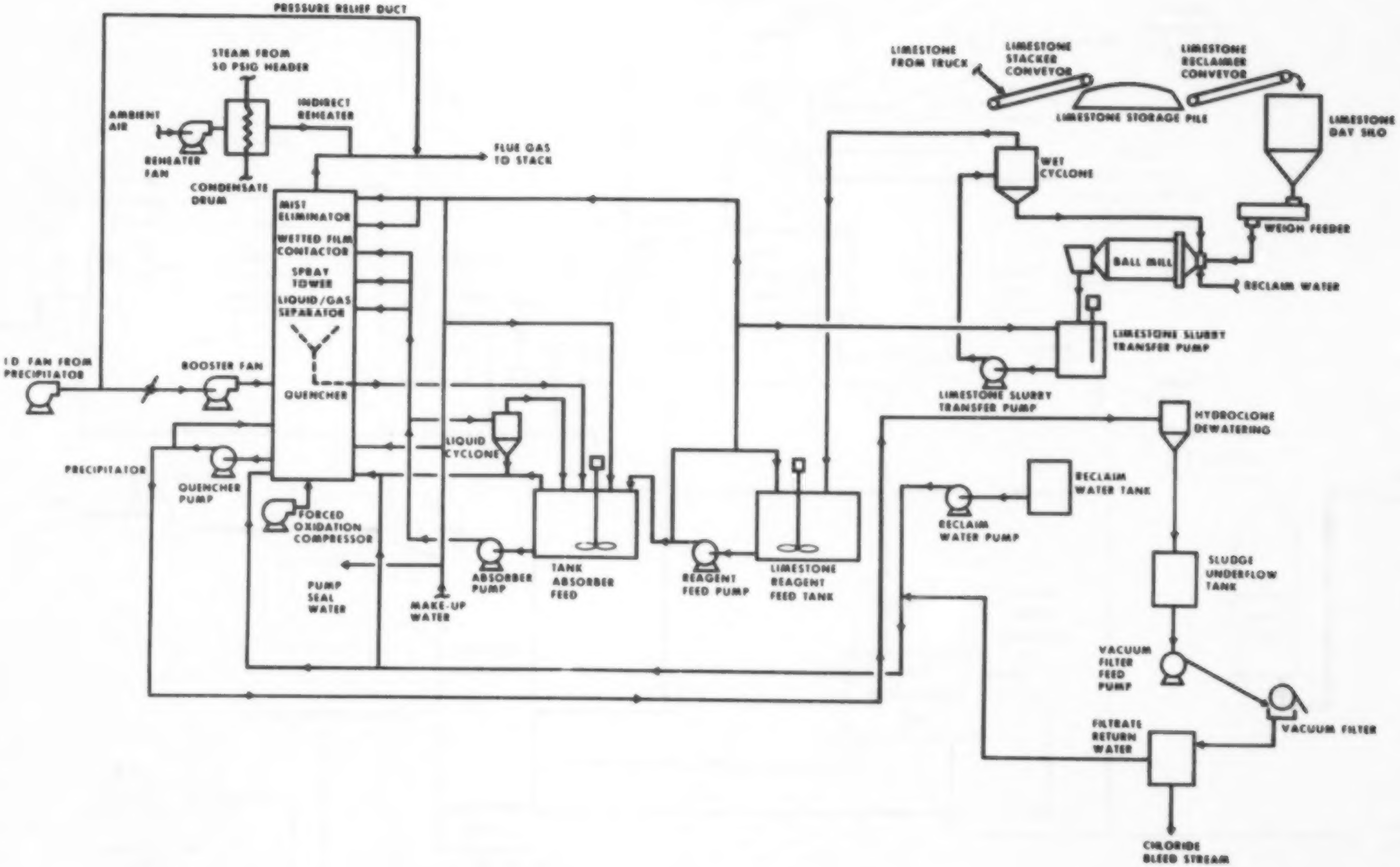

PRESSURE RELIEF DUCT
STEAM FROM 50 PSIG HEADER
AMBIENT AIR
REHEATER FAN
INDIRECT REHEATER
CONDENSATE DRUM
FLUE GAS TO STACK
MIST ELIMINATOR
WETTED FILM CONTACTOR
SPRAY TOWER
LIQUID/GAS SEPARATOR
QUENCHER
I D FAN FROM PRECIPITATOR
BOOSTER FAN
PRECIPITATOR
QUENCHER PUMP
FORCED OXIDATION COMPRESSOR
PUMP SEAL WATER
MAKE-UP WATER
LIQUID CYCLONE
ABSORBER PUMP
TANK ABSORBER FEED
REAGENT FEED PUMP
LIMESTONE REAGENT FEED TANK
LIMESTONE FROM TRUCK
LIMESTONE STACKER CONVEYOR
LIMESTONE STORAGE PILE
LIMESTONE RECLAIMER CONVEYOR
LIMESTONE DAY SILO
WET CYCLONE
WEIGH FEEDER
BALL MILL
RECLAIM WATER
LIMESTONE SLURRY TRANSFER PUMP
LIMESTONE SLURRY TRANSFER PUMP
HYDROCLONE DEWATERING
RECLAIM WATER TANK
RECLAIM WATER PUMP
SLUDGE UNDERFLOW TANK
VACUUM FILTER FEED PUMP
VACUUM FILTER
FILTRATE RETURN WATER
CHLORIDE BLEED STREAM

Figure 3-9. Limestone FGD system at Big Bend Station.

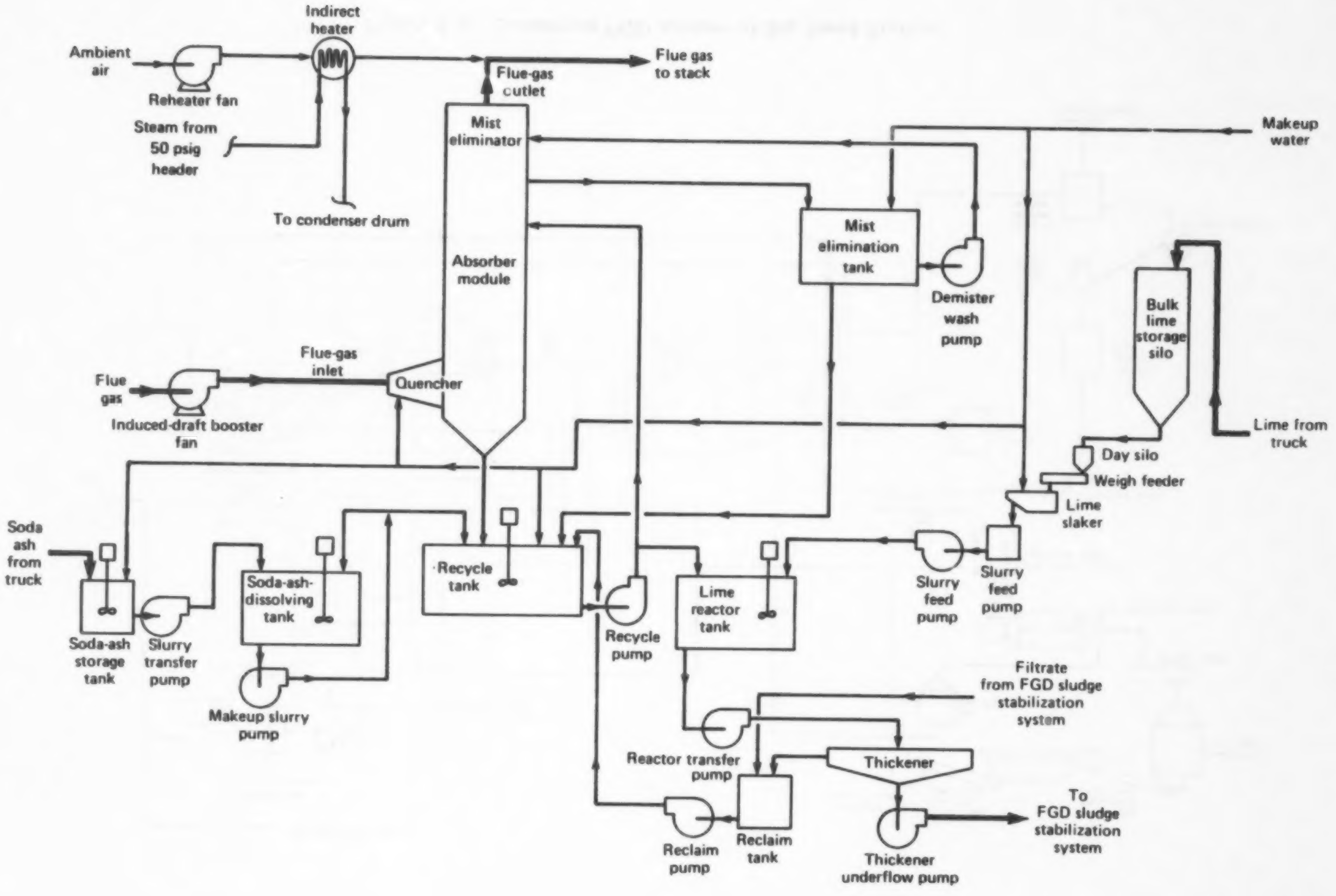

Ambient air
Reheater fan
Indirect heater
Steam from 50 psig header
To condenser drum
Flue gas to stack
Flue-gas outlet
Mist eliminator
Absorber module
Makeup water
Mist elimination tank
Demister wash pump
Bulk lime storage silo
Lime from truck
Day silo
Weigh feeder
Lime slaker
Slurry feed pump
Slurry feed pump
Flue gas
Induced-draft booster fan
Flue-gas inlet
Quencher
Soda ash from truck
Soda-ash storage tank
Slurry transfer pump
Soda-ash-dissolving tank
Makeup slurry pump
Recycle tank
Recycle pump
Lime reactor tank
Filtrate from FGD sludge stabilization system
Reactor transfer pump
Thickener
Reclaim pump
Reclaim tank
Thickener underflow pump
To FGD sludge stabilization system

Figure 3-10. Process flow diagram of the dual-alkali FGD system alternative.

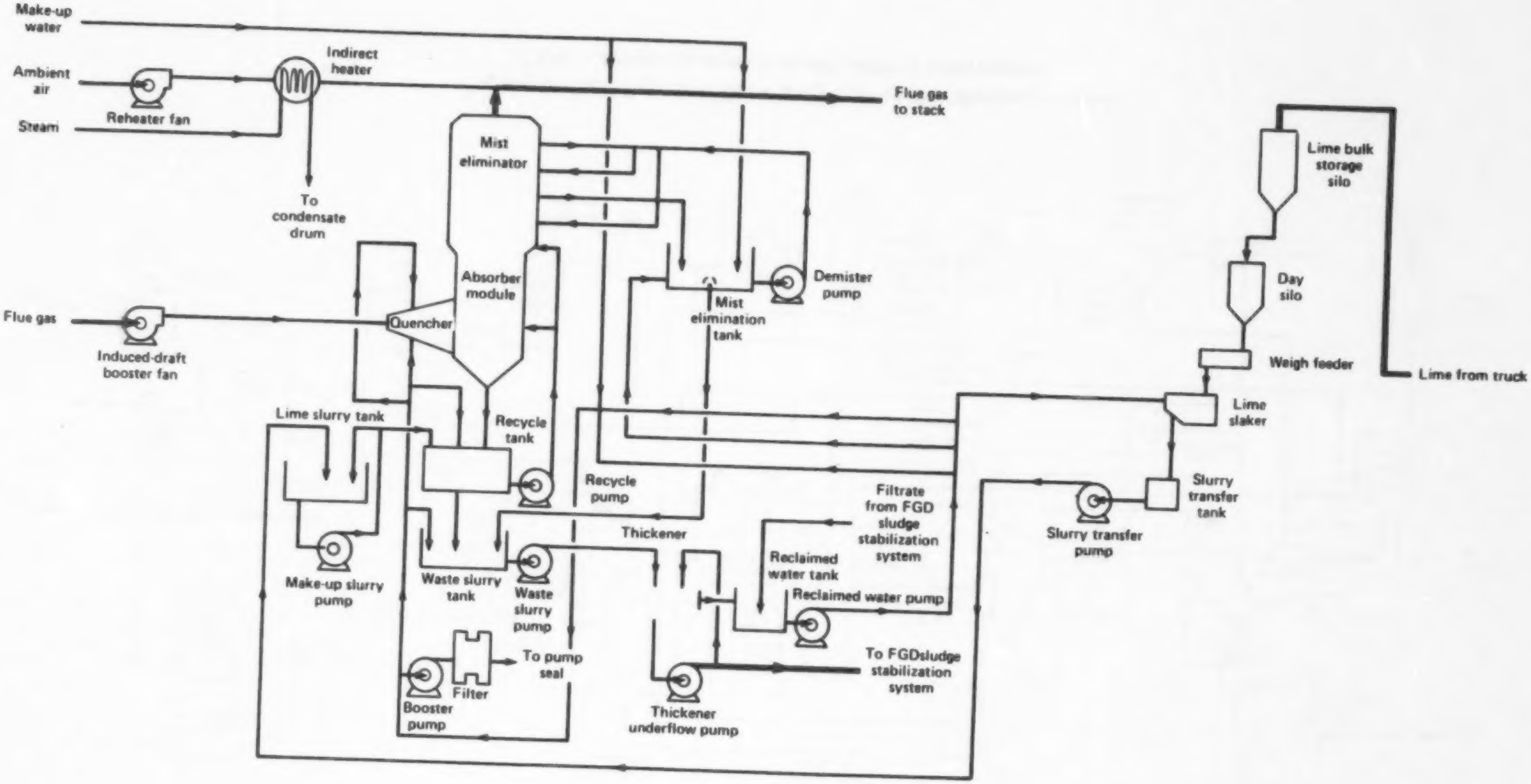

Make-up water
Ambient air
Steam
Reheater fan
Indirect heater
To condensate drum
Flue gas to stack
Mist eliminator
Absorber module
Quencher
Flue gas
Induced-draft booster fan
Mist elimination tank
Demister pump
Lime bulk storage silo
Day silo
Weigh feeder
Lime from truck
Lime slaker
Slurry transfer tank
Slurry transfer pump
Lime slurry tank
Recycle tank
Recycle pump
Make-up slurry pump
Waste slurry tank
Waste slurry pump
Thickener
Filtrate from FGD sludge stabilization system
Reclaimed water tank
Reclaimed water pump
To FGDsludge stabilization system
Thickener underflow pump
Booster pump
Filter
To pump seal

Figure 3-11. Process flow diagram of the lime FGD system alternative.

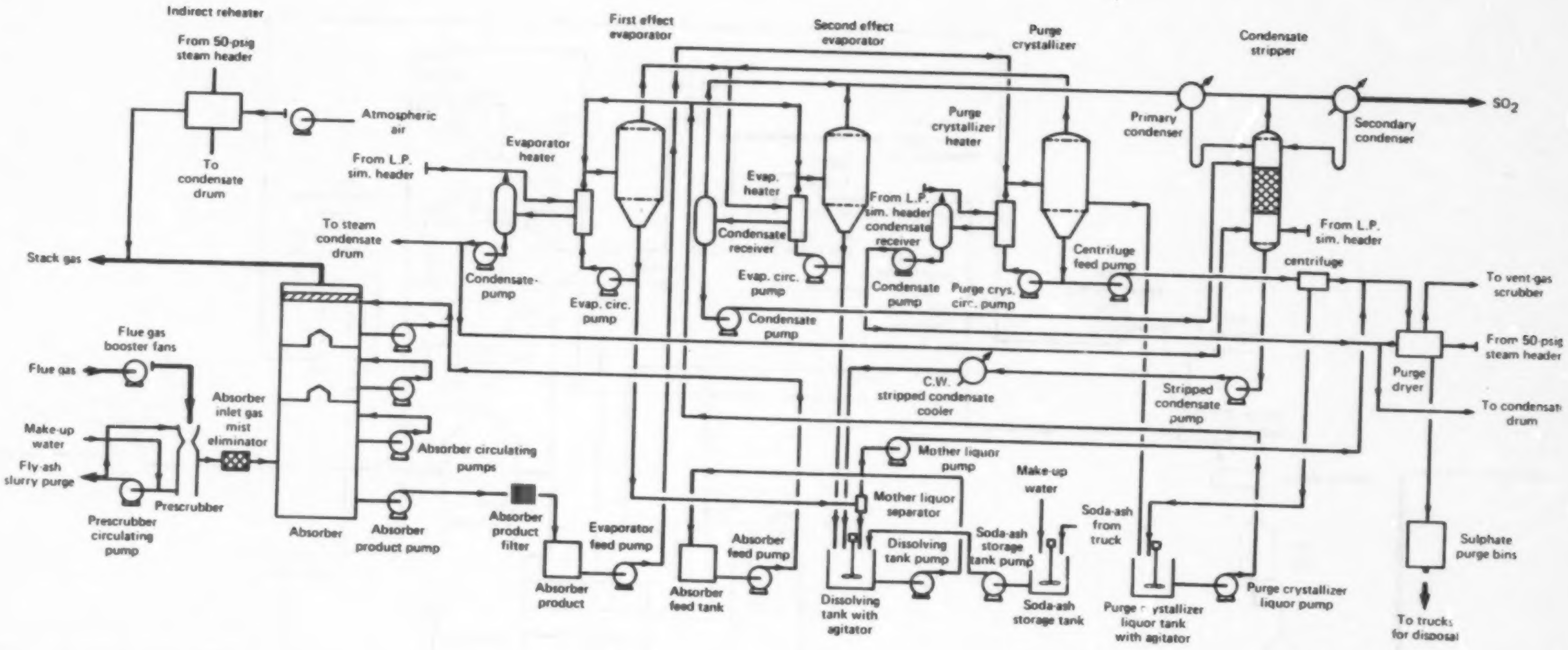

Indirect reheater
From 50-psig steam header
To condensate drum
Atmospheric air
Stack gas
Flue gas booster fans
Flue gas
Make-up water
Fly-ash slurry purge
Prescrubber circulating pump
Prescrubber
Absorber inlet gas mist eliminator
Absorber
Absorber circulating pumps
Absorber product pump
Absorber product filter
Absorber product
Evaporator feed pump
To steam condensate drum
From L.P. sim. header
Evaporator heater
Condensate-pump
First effect evaporator
Evap. circ. pump
Absorber feed tank
Absorber feed pump
Second effect evaporator
Evap. heater
Condensate receiver
Evap. circ. pump
Condensate pump
From L.P. sim. header condensate receiver
Condensate pump
Purge crystallizer heater
Purge crystallizer
Purge crys. circ. pump
Centrifuge feed pump
C.W. stripped condensate cooler
Mother liquor pump
Mother liquor separator
Dissolving tank pump
Dissolving tank with agitator
Make-up water
Soda-ash storage tank pump
Soda-ash storage tank
Soda-ash from truck
Purge crystallizer liquor tank with agitator
Purge crystallizer liquor pump
Primary condenser
Condensate stripper
Secondary condenser
SO_2
From L.P. sim. header
centrifuge
Stripped condensate pump
Purge dryer
To vent-gas scrubber
From 50-psig steam header
To condensate drum
Sulphate purge bins
To trucks for disposal

Figure 3-12. Process flow diagram of the Wellman-Lord FGD system (purge crystallization) alternative.

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Stone & Webster Engineering Corporation. 1979. Heat rejection study, Big Bend Unit 4, Tampa Electric Company. Boston, Massachusetts.

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Chapter 4

PROPOSED PROJECT

4.1 LOCATION AND PLAN OF PROJECT

Figure 4-1 shows the general site location, and the locations of the site and contiguous areas are specified in Figure 4-2. A plot plan of the site showing Unit 4 is presented in Figure 4-3. The site for the proposed Big Bend Generating Unit 4 lies in southern Hillsborough County, Florida, about 5 miles north of Ruskin, on the eastern shore of Hillsborough Bay. Hillsborough Bay is a northeasterly extension of Tampa Bay about 26 miles from Egmont Key, which is at the entrance to Tampa Bay from the Gulf of Mexico. The site is about 10 miles south of the City of Tampa and about 14 miles east of St. Petersburg, across Tampa Bay. Located just north of Big Bend Road, the site is approximately 1 mile west of U.S. Route 41.

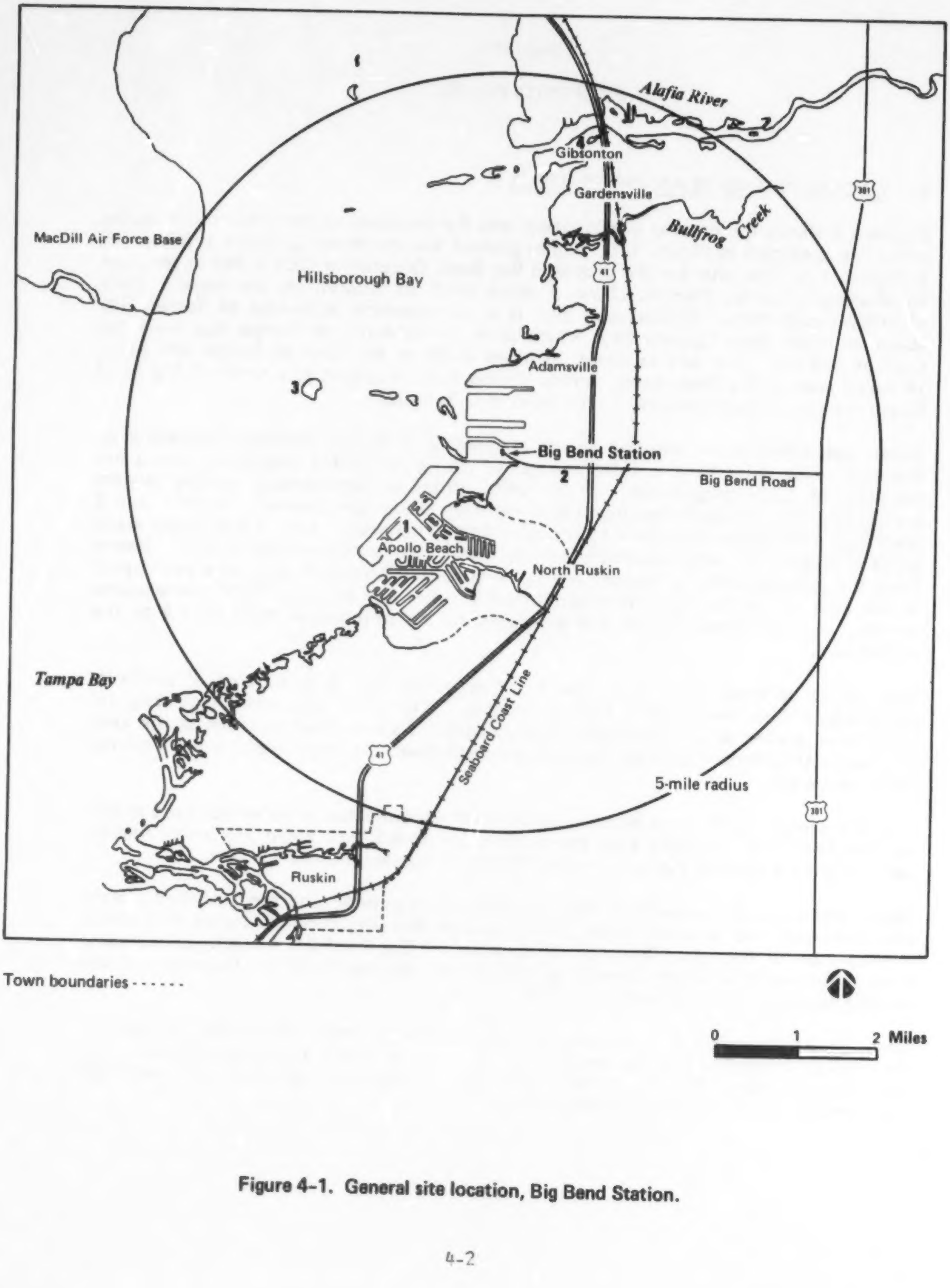
Three coal-fired steam electric power generating units are presently operating on the site. The units have a total nameplate rating of 1,336.5 megawatts and a net capacity of 1,086 megawatts. These units utilize a once-through cooling system discharging into Hillsborough Bay via a common discharge channel. Units 1 and 2 discharge stack gases through a 490-foot common-flue stack. Unit 3 discharges stack gases through a second 490-foot stack that will also accommodate Unit 4. Power from the existing units is transmitted via overhead 230-kilovolt lines to a switchyard on the east side of the site. This switchyard is connected into the TECO transmission system. An additional circuit will be added to transmit power from Unit 4 to the switchyard.

The site of existing Units 1, 2, and 3 and proposed Unit 4 is an area of artificial fill dredged from the bottom soils of the bay. The plant site and surrounding fill have been graded to an essentially flat surface. Natural land surfaces in the area are nearly flat, broken only by shallow stream channels, swampy areas, and occasional depressed areas.

The site area is 1,675 acres in area, all of which is owned by, or under purchase option to, the Applicant. Present yard grade elevation is 8.5 feet mean low water datum, and the ground floor of the existing facilities is at an elevation of 9.0 feet.

Major transportation arteries in the area are U.S. Route 41 and the Seaboard Coastline Railroad, both located about a mile east of the site, and U.S. Route 301, about 4 miles east of the site. The plant is accessed by Big Bend Road and by a rail spur. Fuel is delivered by barge through a dredged ship-access channel. Docking and unloading facilities are provided on the bay.

Commercial operation is scheduled to begin in March 1985. The preferred date to commence construction is November 1981 in order to allow the most efficient construction schedule. The very latest date construction can start, and still meet the commercial operation date, is February 1982.



1
Alafia River
4
Gibsonton
Gardensville
Bullfrog Creek
301
MacDill Air Force Base
Hillsborough Bay
41
Adamsville
3
Big Bend Station
2
Big Bend Road
1
Apollo Beach
North Ruskin
Tampa Bay
Seaboard Coast Line
41
5-mile radius
301
Ruskin
Town boundaries - - - - - -
0
1
2 Miles

Figure 4-1. General site location, Big Bend Station.

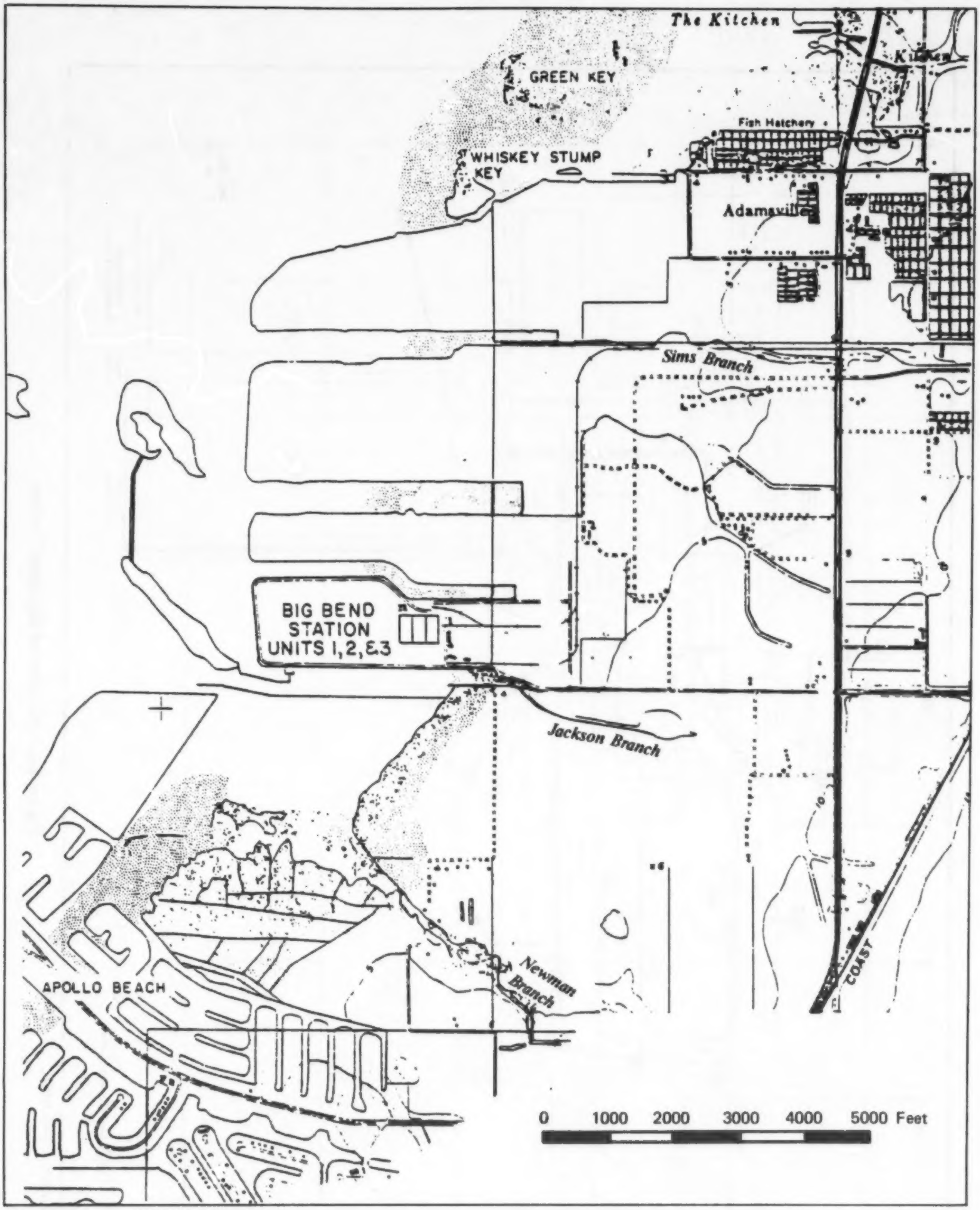
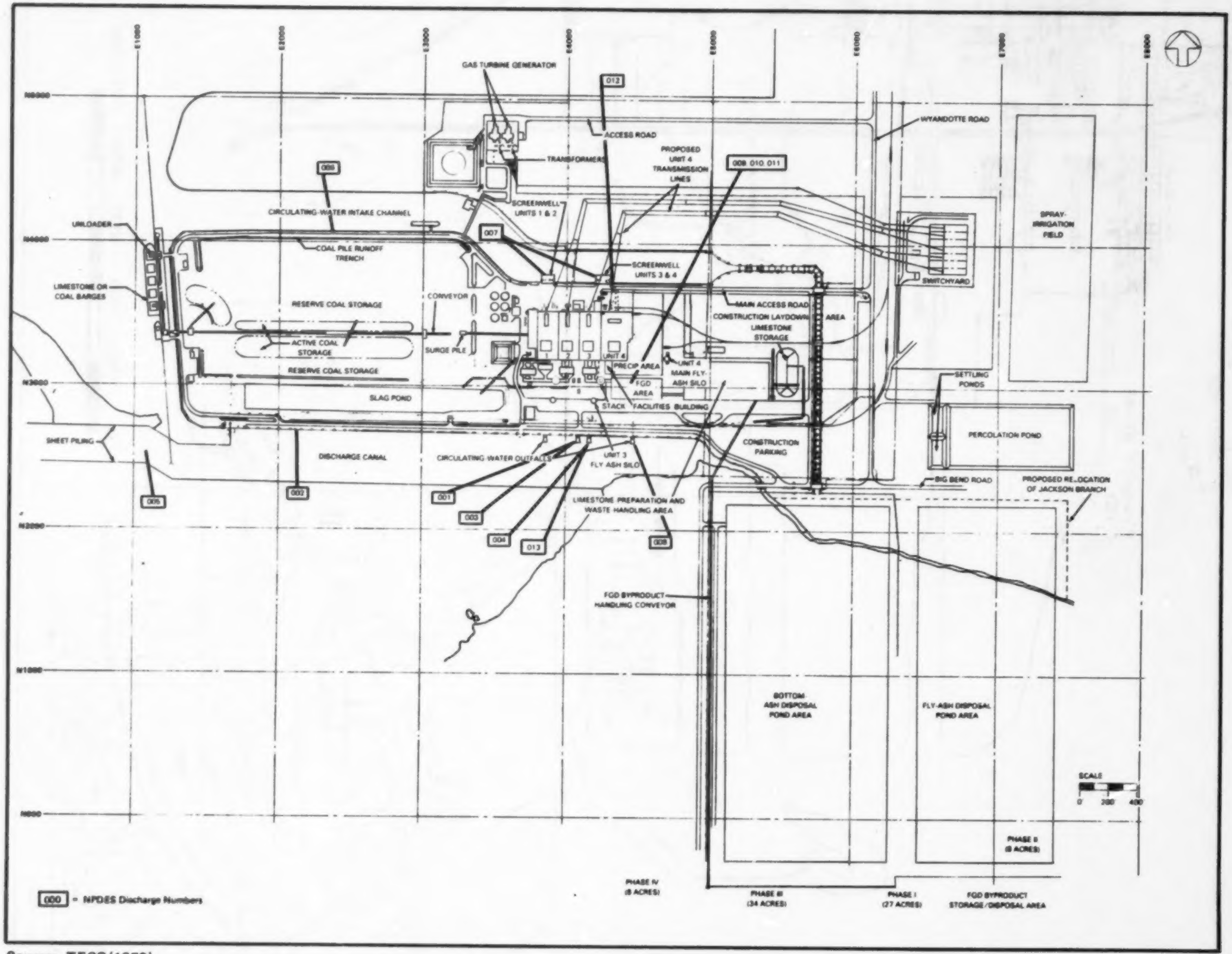

The Kitchen
Kitchen
GREEN KEY
Fish Hatchery
WHISKEY STUMP KEY
Adamsville
Sims Branch
BIG BEND STATION UNITS 1, 2, & 3
Jackson Branch
Newman Branch
APOLLO BEACH
COAST
0
1000
2000
3000
4000
5000 Feet

Figure 4-2. Site and contiguous areas, Big Bend Station.


E1000
E2000
E3000
E4000
E5000
E6000
E7000
E8000
N5000
N4000
N3000
N2000
N1000
N000
GAS TURBINE GENERATOR
012
ACCESS ROAD
TRANSFORMERS
PROPOSED UNIT 4 TRANSMISSION LINES
008 010 011
WYANDOTTE ROAD
SPRAY-IRRIGATION FIELD
009
CIRCULATING-WATER INTAKE CHANNEL
SCREENWELL UNITS 1 & 2
007
UNLOADER
COAL PILE RUNOFF TRENCH
SCREENWELL UNITS 3 & 4
SWITCHYARD
LIMESTONE OR COAL BARGES
RESERVE COAL STORAGE
CONVEYOR
MAIN ACCESS ROAD
CONSTRUCTION LAYDOWN AREA
LIMESTONE STORAGE
ACTIVE COAL STORAGE
SURGE PILE
1
2
3
UNIT 4
PRECIP AREA
UNIT 4 MAIN FLY-ASH SILO
RESERVE COAL STORAGE
FGD AREA
SETTLING PONDS
SLAG POND
STACK
FACILITIES BUILDING
PERCOLATION POND
SHEET PILING
DISCHARGE CANAL
CIRCULATING WATER OUTFALLS
UNIT 3 FLY ASH SILO
CONSTRUCTION PARKING
BIG BEND ROAD
PROPOSED RE-LOCATION OF JACKSON BRANCH
005
002
001
003
004
013
LIMESTONE PREPARATION AND WASTE HANDLING AREA
006
FGD BYPRODUCT HANDLING CONVEYOR
BOTTOM ASH DISPOSAL POND AREA
FLY-ASH DISPOSAL POND AREA
SCALE
0
200
400
PHASE II (8 ACRES)
PHASE IV (8 ACRES)
PHASE III (34 ACRES)
PHASE I (27 ACRES)
FGD BYPRODUCT STORAGE/DISPOSAL AREA
000 = NPDES Discharge Numbers

Source: TECO(1979).

Figure 4-3. Plot plan of Big Bend Station.

4.2 PLANT ELEMENTS

4.2.1 GENERAL DESCRIPTION

The proposed Big Bend Unit 4 will be a one-unit addition to the three units that comprise the existing Big Bend Station. The new unit will have a net capacity of 417 megawatts, giving the total plant a generating capacity of 1,503 megawatts.

Major buildings and structures that comprise Big Bend Unit 4 are the turbine hall, the boiler complex, electrostatic precipitators, flue-gas-desulfurization facilities, flue-gas-desulfurization by-product handling and storage facilities, and condenser-cooling-water intake and discharge structures. The unit is designed to share certain existing structures and facilities with the existing units, including a stack, transmission towers, and coal unloading and handling facilities.

The turbine room and boiler complex will be an extension of the existing station structures. Stack gases will be exhausted via the stack constructed with Unit 3, which stack was designed to accommodate Units 3 and 4.

Unit 4 is functional in design. The turbine hall is enclosed in a steel frame sheathed with structural siding, and it is an easterly extension of the existing hall. The service facilities are extensions of this dominant mass. The boiler, rising above it, is exposed and offers a complex of forms contrasting with the simple, rectangular turbine building.

Architecturally, the structure is an interesting balance of shape, mass, and detail. The corners of the turbine building are sharply defined in a reentrant motif. Natural light is admitted to the interior through continuous, translucent plastic panels that form a cornice band at the top of the structure.

The appearance of the plant is enhanced by color, interior as well as exterior. The siding color selected for Unit 4 is pale gray, which blends well with the oyster white of Units 1, 2, and 3. The buildings are to be trimmed in cranberry red. The exposed steel framing supporting the Unit 3 boiler is painted a bright yellow, contrasting with the cerulean blue applied to the coal bunkers and exposed steel supporting the precipitator. The cranberry color is also used to accent the exposed columns supporting the enclosed conveyor house. This color scheme is repeated for the adjacent Unit 4 boiler, bunkers, and precipitator structures. The dual contrast, blue accenting the yellow of the mechanical forms, and cranberry red accenting the pale gray of the solid masses, is consistent throughout the plant complex.

The color scheme is particularly effective for the coal unloader and stacker, a unique facility located on the seawall. The strong colors dramatize the moving parts of this enormous and complex mechanism.

Seen from the bay, Big Bend Station presents an interesting structural profile and a pleasing combination of colors. The areas immediately around the main approaches and entrances are appropriately landscaped.

4.2.2 STEAM AND ELECTRIC POWER GENERATION SYSTEMS

Major components of the steam and electric power generation systems are the boiler, the turbine generator, the condenser, pumps, and heaters. A schematic of the system is presented as Figure 4-4. Coal is burned in the boiler and the heat is used to generate high-pressure, superheated steam. The steam from the boiler passes through the high-pressure (HP) section of the turbine where a portion of the thermal energy is converted to the mechanical energy of turbine rotation. The steam emerges at a lower temperature and pressure, then is returned to the boiler, where it is reheated. Steam from the reheater passes through the intermediate-pressure (IP) and low-pressure (LP) sections of the turbine, where additional thermal energy is converted to mechanical energy. The steam from the LP turbine is exhausted at subatmospheric pressure to the condenser, where it is condensed to water. Heat from the condensing steam is absorbed by cooling water passing through the condenser tubes. The condensate from the condenser is pumped back into the boiler. Prior to entering the boiler it is heated by steam extracted from the turbine. The mechanical energy of rotation of the turbine-generator shaft is converted to electric energy in the generator. The following are the major operating parameters of the steam-generated electric power system:

Pressure of steam entering HP turbine	2,520 psig
Temperature of steam entering HP turbine	1,000°F
Temperature of steam entering IP turbine	1,000°F
Pressure of steam leaving LP turbine	3.45 inches of mercury
Temperature of steam leaving LP turbine	120°F

4.2.3 PLANT WATER SYSTEMS

4.2.3.1 Station Water Use

The plant is served by the South/Central Hillsborough County water system for most of its freshwater needs. County water use by Big Bend Units 1, 2, and 3 has been 1.1 million gallons per day (average). Estimates show the need for an additional 2.1 million gallons per day (mgd) for Unit 4, with the flue-gas-desulfurization (FGD) system using the majority of that water.

Hillsborough Bay, the source of once-through cooling water for Big Bend Units 1, 2, and 3, is the proposed source for the Unit 4 once-through cooling water. The combined discharge of Units 1, 2, and 3 totals 1,611 cubic feet per second (cfs). The combined discharge of Units 1, 2, 3, and 4 will total 2,148 cfs.

Figure 4-5 shows the plant water balance for Unit 4, and a breakdown of facility water use is provided as Table 4-1.

4.2.3.2 Makeup Demineralizer System

Well water taken from the county system supplies water to the demineralizer equipment presently used to provide high quality makeup water for the plant.

A typical analysis of this water supply is as follows:

Parameter	Parts per million (ppm)
Calcium (as Ca^{2+})	74
Magnesium (as Mg^{2+})	30
Sodium (as Na^+)	13
Bicarbonate (as HCO_3)	198
Chloride (as Cl^-)	27
Sulfate (as SO_4)	129
Fluoride (as Fl^-)	0.5
Silica (as SiO_4)	32
Total dissolved solids	510
Free CO_2 (as CO_2)	5
Total hardness(as $CaCO_3$)	306
Total alkalinity (as $CaCO_3$)	162
pH	7.5-7.9
Temperature	60-80°F
Settleable substances	30

No additional demineralizer equipment is proposed for Unit 4, since existing Unit 3 facilities have the capability to furnish the required makeup.

The existing demineralizer facility consists of two trains of units, each train consisting of an activated carbon unit, a cation exchange unit, a forced-draft decarbonator, an anion exchange unit, and a mixed-bed exchange unit operating in series. Demineralized-water discharges are stored in two 500,000-gallon storage tanks.

Each train can supply up to 600 gallons per minute (gpm) of demineralized water, which will provide system reliability under maximum power operation.

Expected consumption values of water for the makeup demineralizer system are listed in Table 4-2.

4.2.3.3 Condensate-Polishing Demineralizer System

A condensate-polishing demineralizer system is required for Unit 4 to maintain the following condensate water quality:

Sodium (as Na)	3 parts per billion (ppb)
Chlorides (as Cl)	4.5 ppb
Specific conductivity at 25°F	0.10 μmho/cc max
Total solids (dissolved and suspended)	27 ppb max
Total silica (as SiO_2)	10 ppb max
Metallic impurities (as the metal)	10 ppb, of which copper shall not exceed 2 ppb and iron 5 ppb
Total hardness (as $CaCO_3$)	0
pH (before NH_3 break)	6.5-7.5
pH (after NH_3 break)	8.8-9.6

There will be a total of three condensate-polishing demineralizer units (two operating and one spare). The design-flow rate for two operating units is 6,000 gpm. The design temperature and pressure are 135°F and 500 psi, respectively.

4.2.3.4 Cooling-Water System

The condenser-cooling-water systems of the existing and proposed units at Big Bend are described in Section 4.2.4. Flow and velocity characteristics of the systems are presented in Table 4-3.

4.2.3.5 FGD System

An FGD is required for Unit 4 to meet state and Federal emission and air-quality standards. A limestone system requires a makeup-water source for the sulfur dioxide removal process. An estimated 1.1 million gallons per day (mgd) is required as makeup for the proposed system.

Current plans are to utilize water from the Hillsborough County South/Central System. In order to minimize the plant's demand on this municipal system, the Applicant has evaluated the use of water from other sources. The most promising source would be sewage treatment plant effluent from Sun City Center, since its quality is compatible with the requirements of the FGD system. TECO has been included in the Hillsborough County South 201 Facility Plan for reuse of the sewage-treatment-plant effluent. The plan provides for 1.5 mgd available for Big Bend in 1986.

4.2.3.6 Bottom-Ash Sluice System

The Unit 4 boiler will be of the dry-bottom type and will be provided with a recirculating freshwater sluice system to transport ash to a disposal pond. Makeup-water requirements to the ash-sluice system will be approximately 505,000 gallons per day (gpd). The system requires a blowdown of 115,000 gpd to the discharge channel.

4.2.3.7 Fly Ash, Pyrites, and Economizer Sluice System

Unit 4 will be provided with a closed-loop freshwater fly-ash-sluice system for handling fly ash, economizer ash, and pyrites. The system will transport these materials to an onsite disposal pond. Makeup-water requirements for this system will be approximately 54,600 gpd.

4.2.3.8 Other Water Uses

There will be many minor water uses associated with Unit 4. These include service cooling water, fire-protection water, pump and equipment seal water, and domestic water. In addition, plant recycle water will be used for such purposes as washing of the air preheater, precipitator, and boiler. Anticipated water quantities for these uses are indicated in Table 4-1.

4.2.3.9 Chemical and Biocide Wastes

The wastewater system consists of an in-plant collection and transportation system, a wastewater-treatment-pond system, a spray-irrigation system, and a recycle system. The wastewater-treatment-pond and spray-irrigation systems were fully operational on July 1, 1977. The recycle system commenced operation on September 1, 1978. Chemical and biocide wastewater and the sanitary-system effluent will be treated in the wastewater ponds.

Liquid wastes associated with the operation of Big Bend Unit 4 will include the following:

- Water-treatment and condensate-polisher wastes*
- Equipment-washing and boiler-chemical-cleaning wastes*
- Floor and equipment drainage*
- Boiler blowdown
- Blowdown from the service-water cooling-tower system*
- Bottom-ash sluice-system blowdown
- Ash-sluicing wastes
- FGD chloride-bleed stream
- Runoff from the coal-storage pile
- Sanitary wastes

4.2.3.10 Chemical Wastes

4.2.3.10.1 Water-Treatment Wastes

The makeup-water-treatment system consists of activated carbon filters; cation, anion, and mixed-bed demineralizers; and a forced-draft decarbonator. In addition, a condensate polisher will be used for further treatment of the condenser water.

The activated carbon filter is automatically backwashed when the pressure drop across the bed reaches a predetermined value. Backwashing removes small quantities of suspended matter and reactivates the activated carbon bed. Effluent from backwashing will be conveyed to the Unit 1 washwater sump for transport to the station wastewater-treatment system.

The ion-exchange demineralizers will be regenerated using sulfuric acid for the cation resins and caustic soda for the anion resins. Wastes from the regeneration of the cation and anion demineralizers, the mixed-bed demineralizers, and the condensate polishers will be pumped to the 230,000-gallon waste-neutralization tank for equalization and partial neutralization of spent acid and caustic.

The cation and anion exchangers will be regenerated every 45 hours during normal plant operation and every 24 hours under maximum load, resulting in approximately 112,000 gallons of waste. The mixed-bed demineralizers will be regenerated approximately every 20 days, resulting in approximately 30,000 gallons of waste, and the condensate polishers will be regenerated approximately once per month, resulting in approximately 60,000 gallons of waste.

The regeneration waste from the condensate polisher/demineralizer will contain suspended and dissolved solids such as sodium chloride, sodium sulfate, and either ammonium sulfate or calcium sulfate. Quantities and concentrations of these wastes depend on the manufacturer and/or the system purchased. The equalized regeneration wastes flow to the Unit 1 washwater sump and are then pumped to the wastewater-treatment ponds.

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*These wastes associated with Units 1, 2, and 3 are presently being transported to the wastewater ponds for treatment and disposal. Unit 4 waste will also be conveyed to the wastewater-treatment ponds.

4.2.3.10.2 Equipment Washing and Boiler-Chemical Cleaning

Accumulation of deposits on equipment surfaces will necessitate washing of the air preheaters, economizers, and precipitators every 12 to 26 weeks with the recycle wash system water. The air preheater will be washed at a maximum flow rate of 2,140 gpm, and the economizer and precipitator will be washed at a flow rate of 50 and 400 gpm. The spent washwater will contain soluble metals (principally iron) and will have a pH between 1.4 and 4.0.

Chemical cleaning of the boiler and preboiler system prior to startup is necessary to provide clean, properly conditioned heat-transfer surfaces and thus ensure reliable unit operation.

The preoperational chemical cleaning of the boiler and preboiler involves the following steps:

1. Freshwater flush
2. Emulsifier washout (200 gallons in water)
3. Alkaline flush (0.5 percent trisodium phosphate and 0.5 percent disodium phosphate)
4. Freshwater flush
5. Acid flush (3 percent citric acid and 1,000 gallons concentrated ammonium hydroxide or 5 percent inhibited hydrochloric acid)
6. Freshwater flush
7. Neutralization (1 percent sodium carbonate)
8. Passivation (0.25 percent monosodium and disodium phosphate plus 0.5 percent sodium nitrate)

Postoperational chemical cleaning of the boiler will occur approximately every 2 years and will include the following stages:

1. Acid introduction (5 percent inhibited hydrochloric acid)
2. Freshwater rinse
3. Neutralization (1 percent sodium carbonate)

Equipment washwaters are pumped from the washwater sump and disposed of in the wastewater-treatment ponds.

4.2.3.10.3 Floor and Equipment Drainage

Floor and equipment drainage will be collected and conveyed to the wastewater-treatment ponds.

Drainage from the diked fuel-oil-storage areas and fuel oil pumphouse will be conveyed to an oil separator. Oil-free water from the separator will be discharged to the intake channel. Collected oil will be drummed for reuse.

4.2.3.10.4 Boiler Blowdown

During normal station operation, approximately 30 gpm of water will be blown down continuously from the steam drum and replaced with demineralized water. Blowdown is required to maintain total dissolved solids and silica levels below 50 ppm and 10 ppb, respectively, to ensure reliable boiler operation. Small quantities of aqua ammonia and hydrazine are used to control system pH and to remove trace quantities of dissolved oxygen, respectively, within the boiler and preboiler systems. Boiler blowdown will flow to the Unit 4 condenser-cooling-water discharge pipe.

4.2.3.10.5 Service-Water Cooling-Tower Blowdown

Well water from Hillsborough County will be used as makeup to a wet-evaporative mechanical-draft cooling tower serving heat exchangers such as turbine-lube-oil coolers and bearing-water coolers. Small quantities of sulfuric acid will be added to the recirculating water to control calcium carbonate scaling by reducing the bicarbonate alkalinity. Blowdown from the cooling tower will be required to keep dissolved solids at levels that are consistent with reliable operation. Approximately 50 gpm of water will be continuously blown down from the tower and discharged to the washwater sump prior to being pumped to the wastewater-treatment ponds.

4.2.3.10.6 Slag/Ash-Handling System

The boilers for Units 1, 2, and 3 are equipped with wet-bottom slag-handling systems. The molten slag falls by gravity from the bottom of the boiler fireside into one of two slag tanks located directly under each boiler. Cooling water is pumped through the slag tanks to cool the slag, which solidifies and shatters into pieces approximately 1/4 inch in diameter. The clear overflow from this system is conveyed to the slag pond prior to discharge.

The slag-sluicing system uses saltwater as the sluicing medium to eject the slag from the bottom of the slag tank. A 25-percent slag slurry is pumped from the tanks by hydroejectors to the slag pond. Since the slurry contains only suspended solids, the only treatment provided is sedimentation. Clear overflow from the slag pond is discharged by gravity to the discharge channel. A schematic of this system is shown in Figure 4-6.

The boiler for Unit 4 will be of the dry-bottom type and will be provided with a freshwater eductor system to transport ash to the bottom-ash pond.

In order to maintain the correct system water chemistry, a blowdown will be required. The blowdown flow rate will be equal to 5 percent of the system flow rate, and the blowdown will be discharged to the Unit 4 condenser-cooling-water discharge pipe.

4.2.3.10.7 Wastes from Fly Ash, Economizer Ash, and Pyrites Sluicing

In order to control scaling within the sluice system, 5 percent of the sluice flow will be blown down to the existing plant wastewater pond.

4.2.3.10.8 FGD System Chloride-Bleed Stream

During operation of the FGD system, the liquid in the quencher/prescrubber loop and throughout the waste-handling system will become concentrated in chlorides. To prevent material corrosion of this loop and to allow production of a commercial grade of gypsum, it is necessary to provide a blowdown, either intermittent or continuous. This blowdown, referred to as the FGD system chloride-bleed stream, will be treated for total suspended solids, pH, and oil and grease using a skid-mounted liquid-waste-treatment system. The flow will enter a primary sedimentation tank equipped with a polymer feed system, where the majority of solids will settle. The type of polymer, which will be used as a coagulant aid, will be determined after the system is in operation. The system has been designed to handle flow rates up to 70 gpm. After the sedimentation, the waste stream will be checked for pH and adjusted to a value between 6.5 and 7.0 by adding either sodium hydroxide or sulfuric acid. The waste stream will then enter a clarifier for final effluent polishing before discharge. After polishing, the flow will be discharged into the Unit 4 condenser-cooling-water discharge pipe. Sludge from the sedimentation tank and clarifier will be disposed of in the FGD by-product storage/handling area.

4.2.3.11 Wastewater-Treatment System

A wastewater-treatment system was installed during 1976 and 1977 to permit compliance with provisions of the National Pollution Discharge Elimination System (NPDES) permit issued by the EPA on March 31, 1976. The system provides for:

- Saltwater waste
- Freshwater waste
- Material storage runoff
- Sanitary wastes

The system now serves Units 1, 2, and 3 and has been sized to receive the wastes from the proposed Unit 4.

4.2.3.11.1 Saltwater Wastes

Unlike Units 1, 2, and 3, there are no saltwater-waste streams associated with Unit 4.

4.2.3.11.2 Freshwater Wastes

Freshwater wastes produced by the proposed Unit 4, other than boiler blowdown, bottom-ash sluice system blowdown, and FGD chloride-bleed stream, will be managed in the same way as wastes from the existing units. All freshwater in-plant waste streams, both continuous and intermittent, are captured by the in-plant collection system. This system consists of a series of sumps and piping throughout the plant area that receives wastewater from washing operations, equipment drains, etc., and conveys it to the main transfer sump. In turn, the mixture of wastewaters is conveyed to the wastewater-treatment ponds.

The approximate chemical composition of the freshwater-waste streams presently entering the system is shown in Table 4-3.

Consideration is being given to a future refinement of the system, specifically, the isolation of intermittent waste streams, such as the equipment-washing and the boiler-chemical-cleaning wastes. This would be done in the interest of preserving water quality in the holding pond. As discussed later, these waters will ultimately be recycled for equipment-washing purposes or disposed of through spray irrigation.

4.2.3.11.3 Wastewater-Treatment Ponds

The wastewater is pumped from the main transfer sump located at the plant through two parallel fiberglass-reinforced pipe (FRP) wastewater pipelines, one 8 inches and the other 10 inches in diameter. Three 1,250-gpm pumps located within the transfer sump discharge into these lines through a manifold arrangement and deliver water to the ponds about 2,000 feet to the east. Figure 4-7 shows a second manifold arrangement located at the settling basins. This arrangement combines the flow from the two pipelines and allows the selection of discharge into either or both of the settling basins. The wastewater enters the settling basins through an FRP multiport-flow distribution manifold 12 inches in diameter. A major portion of the suspended solids settles out, forming a sludge layer within the basin that must be removed periodically. The clarified wastewater is transferred from each settling basin to the retention pond by submerged transfer pipes leading to the settling basin effluent structures. Each of the effluent structures consists of a concrete sump, inlet and outlet piping, and a 90-degree V-notch weir.

At this time, treatment of the wastewater is limited to the removal of settleable solids within the settling basins and self-neutralization within the system of ponds. Each settling pond is approximately 200 feet long and 50 feet wide. The retention pond is approximately 900 feet long and 450 feet wide, has a volume of approximately 25 million gallons at a pond elevation of 11 feet, and has retention times on the order of 20 to 40 days. This large volume provides for neutralization of the individual acidic and basic waste streams. Each settling basin has a design volume of approximately 456,300 gallons, resulting in a retention time of approximately 19 hours at the design average daily flow of 400 gpm per basin. Operations records indicate flows on the order of 500 to 700 gpm, with peaks as high as 2,800 gpm.

Three pipes are presently capable of discharging water from the pond; two are valved drain pipes, and the third is an unvalved overflow pipe. TECO proposes installing a valve on the overflow pipe and locking all three of the valves. Keys will be given only to selected supervisory personnel.

TECO will also install an alarm system to signal high water levels in the pond. Should levels become dangerously high, excess water will be pumped to the spray-irrigation fields. If, for emergency reasons, any of the valves are opened to discharge water from the pond, a report will be sent to the EPA, stating why the valve was opened, the estimated volume of water discharged, the time of the discharge, and an analysis of the water sampled during discharge.

4.2.3.11.4 Spray-Irrigation System

The spray-irrigation system consists of pumps, piping, valving, controls, and other appurtenances for the purpose of providing land application and disposal of that portion of the wastewater within the retention pond in excess of the demand for recycled wastewater at the plant. The spray-irrigation site consists of approximately 29 acres of land lying within the transmission right-of-way located directly north of and adjacent to the retention pond, as shown in Figure 4-7. Approximately 21.1 acres are actually to be irrigated, and the remainder are to comprise the nonirrigated buffer zone. The site consists of four separate irrigation plots of approximately 5.25 acres each. Wastewater from the retention pond will be applied as required to one irrigation plot per day on a rotation basis. Irrigation is by means of a fixed system of four impact sprinklers per plot. Plot rotation is accomplished manually through actuation of the 6-inch butterfly valves located on each of the laterals leading to the four irrigation plots.

As a practical matter, the application rate is governed by pond level, seasonal conditions, and ground-water level. The overriding criterion for system operation is avoidance of runoff from the sprayed area. When runoff is not a limiting condition, application rates of from 2 to 4 in./week are considered. For a rate of 2 in./week, each of the four plots must be sprayed 2 hr/d; for a rate of 4 in./week, each plot must be sprayed 4 hr/d. This provides ultimate water disposal ranging from 254,400 to 508,800 gpd. An 8-inch-propeller flowmeter is located in the pump discharge manifold to measure the total quantity of wastewater disposed of by spray irrigation.

Wastewater is transferred from the retention pond to the pumping station via two pump suction lines installed through the pond embankment. An 8-inch FRP suction line serves two spray-irrigation pumps. A 10-inch FRP suction line serves two recycle pumps.

A stilling well is attached to the pond drain line, and it houses the water-level probes which serve to control both spray irrigation and recycle pump operation and to actuate the pond high- and low-water-level alarms.

The spray-irrigation pumps are end-suction centrifugal pumps. The pumps are rated at 530 gpm at 225 feet total developed head (TDH) and are of all stainless steel construction.

4.2.3.11.5 Coal-Pile Runoff

Coal-pile-runoff collection and treatment systems have been provided in order to achieve compliance with limitations established in the NPDES permit. The existing system will be modified to provide for the coal field expansion to accommodate Unit 4.

The system, as it presently exists, consists of an interception trench, a pumping station, and a runoff pond. The system is designed to capture and retain runoff resulting from the "design" storm established by the EPA. The design storm is defined as a 24-hour storm with a recurrence interval of 10 years. Runoff resulting from storms in excess of these design conditions is discharged to Tampa Bay.

To allow for Unit 4 coal storage, the coal-pile-runoff pond will be eliminated. The existing interception trench will be expanded to encircle the new coal-storage area and the pumping station will be relocated. According to the Applicant's preliminary design, 2,500 feet of the existing trench forming the southern and a portion of the eastern perimeter of the coal pile will continue to be used. The existing cross-sectional area is 45 square feet with a top width of 20 feet and 2:1 H:V side slopes. A new portion of trench enclosing the northern end and portions of the eastern and western ends of the coal pile will be 2,200 feet long. This new trench will have a cross-sectional area of 72 square feet with a top width of 30 feet and 2:1 H:V side slopes. The new coal-pile-runoff trench configuration will provide the same storage volume per area as the existing system. The pumping capacity will be designed to handle all surface runoff. The modified system will intercept all surface runoff, including that in excess of the 10-year/24-hour storm, and pump it to the existing demineralizer-waste sump for transfer to the wastewater pond.

The layout of the coal-pile-runoff collection and treatment system at Big Bend Station is presented in Figure 4-8.

4.2.3.11.6 Limestone-Pile-Runoff System

A limestone pile will be maintained at the site and will have adequate storage capacity to ensure the reliability of the Unit 4 FGD system. Limestone will be stored in an enclosed building. Consequently, no limestone-pile-stormwater runoff will be generated.

4.2.3.11.7 Recycle System

The wastewater-recycle system consists of pumps, piping, valving, controls, and other appurtenances for the purpose of transferring water from the wastewater-retention pond to a 500,000-gallon storage tank located at the plant (Figure 4-9). Wastewater will then be reused for various washing and maintenance operations. The recycled-water storage tank is located west of Unit 1, where it was previously used for service water in conjunction with two other 500,000-gallon service-water tanks and two additional 500,000-gallon demineralized-water storage tanks. An in-plant piping system has been installed specifically for recycle purposes.

The recycle pumps discharge through a steel manifold to a 10-inch polyvinyl chloride recycle pipeline that is routed to the storage tank. A 10-inch-propeller flowmeter measures the total flow of recycled wastewater. Valving is provided in the recycle pipeline to allow discharge of the wastewater from the retention pond into the ash-settling canal.

The operation of the recycle pumps is automatically controlled by liquid-level-sensing probes located within the wastewater-recycle storage tank and within the retention-pond stilling well. The objective of the recycle pump control system is to supply the storage tank in response to withdrawals made from the tank and thus to maintain a continuous supply of water for anticipated needs. Table 4-4 lists the plant operations which are expected to utilize the recycled wastewater and their respective water requirements. Items 1, 2, 3, 4, and 8 are expected to occur simultaneously or in succession and represent the maximum anticipated daily water demand of 1,619,400 gpd. The wastewater-recycle system was designed to meet this anticipated demand.

The wastewater-recycle pumps are rated at 1,050 gpm at 68 feet TDH. Both pumps operating simultaneously will deliver approximately 1,500 gpm.

4.2.3.12 Sanitary Wastes

Wastewater from all station sanitary fixtures is collected and conveyed to an existing package sewage treatment plant. This plant, which uses the extended-aeration, aerobic digestion process, was installed with Unit 1 and sized to accommodate future enlargements of the station. The plant has a capacity of 4,500 gpd of domestic sewage, representing an influent 5-day BOD of 9 lb/d based on a 24-hr runoff and a maximum flow rate of 9.6 gpm.

Effluent from the treatment plant is disinfected with chlorine and then discharged to the plant wastewater-treatment system. Thus, its fate is ultimate disposal through spray irrigation.

The treatment plant is designed to achieve a raw sewage 5-day BOD reduction of 90 percent and a suspended-solids reduction of 90 percent. These design efficiencies are in accordance with state requirements. BOD and suspended-solids reduction information, as well as other data, are submitted monthly to the Hillsborough County Environmental Protection Commission and the FDER.

Manpower projections for the operation and maintenance of Big Bend Unit 4 indicate that a second packaged treatment plant will be required. This new plant will provide secondary treatment with design removal efficiencies of 90 percent for BOD_5 and suspended solids. The effluent from the new plant will be chlorinated and discharged to the plant's wastewater system. This system will be operated in accordance with Chapter 17-6 of the Florida Administrative Code in providing for 90 percent treatment and alternate effluent disposal.

4.2.4 CONDENSER-COOLING-WATER SYSTEM

The Applicant proposes to use a once-through condenser-cooling-water system with Unit 4. The basic design will be similar to that of the existing Big Bend units, with one exception: The conventional intake structures for Units 3 and 4 will be surrounded by a fine-mesh (0.5 mm) screen facility. Important aspects of the design and operation of the circulating-water systems of both the existing and proposed units are described below.

4.2.4.1 Existing Units

The site presently consists of three coal-fired, steam-electric generating units. Units 1, 2, and 3 have a total nameplate rating of 1,336.5 megawatts (445.5 megawatts each). The units utilize a once-through cooling system discharging to Hillsborough Bay, as illustrated in Figure 3-5. Each unit has a main condenser that is cooled by water withdrawn from the intake channel.

Units 1, 2, and 3 each draw 537 cubic feet per second (cfs) of circulating water from an intake channel that is 25 feet deep. The intake channel draws water from a 34-foot-deep ship access channel. Each unit is equipped with a screenwell structure containing two circulating-water pumps of 268.5-cfs capacity. Figure 3-6 illustrates the screenwell arrangement.

Water is drawn through 3/8-inch (9.5 mm) mesh traveling water screens and is pumped through two 72-inch-diameter pipes to a condenser for each unit. The average water velocity measured immediately in from of the screenwells at the traveling water screens is 1.45 feet per second (fps). Flows in the intkae channel and their respective velocities are presented in Table 4-5.

Pipes from the two outlet water boxes connect to a 9-foot-diameter pipe leading to the discharge structure. The warm circulating water from each unit exits to the discharge channel via the circulating-water discharge structure. The discharge structure is shown in Figure 4-10. Flow from the discharge pipe enters the structure at approximately 8 fps and exits the structure to the discharge channel at less than 2 fps. The circulating waters exiting the three discharge structures flow west through the common discharge channel and return to Hillsborough Bay. The characteristics of the thermal plume produced by Units 1, 2, and 3 are described in Section 6.3.3.

The three Big Bend units utilize chlorine to control biofouling in the once-through cooling system. Big Bend is equipped with a chlorinator which serves one generating unit at a time. It has a maximum feed rate of 10,000 lb/day and has a 100 percent backup chlorinator available. For each unit, actual feed rates range from 5,000 to 8,000 lb/day, with an average of 6,000 lb/day.

Liquid chlorine is evaporated and fed by water injection to the screenwell prior to entering the cooling-water pumps. The solution is added to the cooling water through rubber-lined diffusers. Chlorine is not fed to a unit unless both pumps are operating. The normal chlorination cycle is 20 minutes of feed, three times a day, for each unit. The chlorine concentration is measured at the outfall of each unit during chlorination. The free residual chlorine is limited to 0.2 mg/ at that point.

The intake pipes of the three units at Big Bend are cleaned approximately twice per year to remove shellfish and marine plant growth. Condenser tubes are cleaned manually using plastic plugs that are blown through the tubes by means of water and air. Units 1 and 2 have plugs blown about every 2 weeks, and Unit 3 has plugs blown weekly.

4.2.4.2 Proposed Unit

It is proposed that Unit 4 have a once-through cooling system with a fine-mesh screen (aperture of 0.5 millimeter) facility surrounding the 3/8-inch-mesh traveling water screens of Units 3 and 4. Unit 4 will have a condenser independent of Units 1, 2, and 3, and it will be cooled by water withdrawn from Hillsborough Bay via the existing intake channel. It will have an intake structure in common with Unit 3. Figure 4-3 illustrates the cooling-water system of the existing three units and that proposed for Unit 4.

After passing through the Unit 4 condenser, the water will exit to the existing discharge channel and combine with water discharged from Units 1, 2, and 3. The mixture will flow westerly, returning to Hillsborough Bay.

4.2.4.2.1 Intake System

Unit 4 will draw approximately 537 cfs of circulating water from the existing, 25-feet-deep intake channel. Unit 4 will be provided with a screenwell structure equipped with two 268.5-cfs circulating-water pumps, each with its own 3/8-inch-mesh traveling water screen, similar to those on Units 1, 2, and 3. This traveling-screen structure and that for Unit 3 will be surrounded by a sheet-pile-wall forebay equipped with 0.5-millimeter-mesh traveling water screens. The cooling water will be drawn through the 0.5-millimeter and 3/8-inch-mesh screens by the pumps supplying the Unit 3 and Unit 4 condensers. The average water velocity immediately in front of the 3/8-inch screenwell will be about 1.45 fps. Approach velocities to the 0.5-millimeter-mesh screens will be about 0.5 fps, as discussed below. The combined circulating-water flow rate for the four units will total 2,148 cfs. Flows in the intake channel for the units, and their respective velocities, are indicated in Table 4-5.

As a result of U.S. Environmental Protection Agency (EPA) concern regarding the number of organisms entrained at Big Bend Station Units 1, 2, and 3, the Applicant initiated a multiphase evaluation of alternative intake technologies to identify potential design alternatives for the Unit 4 intake structure.

The evaluation consisted of several tasks, including:

1. Reviewing available intake technologies that might be applied to Big Bend Station to minimize entrainment losses

2. Selecting organism-protection systems that show promise for biological effectiveness and engineering reliability and conducting a more detailed site-specific evaluation of these systems

3. Initiating preliminary studies to evaluate the feasibility of the selected system

4. Conducting detailed studies to prove the effectiveness and reliability of the alternative system

Results of the first three tasks indicated that a fine-mesh-screen system (specifically a modified, dual-flow traveling screen) could reduce the loss of entrained organisms at Big Bend Station. Consequently, more detailed studies to evaluate the fine-mesh-screen concept further were conducted during 1980. These studies involved the construction, operation, and testing of full-scale prototype traveling screens identical in every detail, except width, to a screen which could be incorporated into an actual fine-mesh-screening installation for Unit 4.

The test results show that a fine-mesh-screen system could reduce the entrainment losses at Big Bend by returning viable meroplankton organisms to the Bay system. As a basis for ecological and engineering evaluations of the potential effectiveness of fine-mesh screening at Big Bend Station, a conceptual design for such a system was developed. This design is described below.

The conceptual design was developed on the basis of applying fine-mesh screens to existing Unit 3 and proposed Unit 4. Sheet piling will enclose the pump screenwell area, creating a forebay between the fine-mesh screens and the pumps. A layout of the new screening structure is shown in Figure 4-11.

Each of the six (three for each unit) dual-flow, fine-mesh screens will be fitted in the sheetpile wall, and the intake flow will pass through the screens and discharge into the forebay. The discharge opening will be sized to achieve a uniform flow through the two parallel screen faces. To ensure proper hydraulic conditions at the four circulating-water pumps and a relatively uniform flow through each of the six screens, the forebay will extend from the seawall about 60 feet into the intake channel. The pumps will also be positioned to so distribute the flow that each set of two circulating pumps would draw from three screens.

Stop gates will close the discharge opening in the event that a screen must be stopped or removed for maintenance. For emergency conditions roller gates will be installed in the sheetpile wall between screens and will be opened to supply water to the pumps if the pressure head differential across the screens exceeds 1.5 feet. To screen the flow and protect the pumps and condenser during emergency operation, the existing coarse-mesh (3/8-inch) screens will be maintained on Unit 3 and similar coarse-mesh screens will be installed on Unit 4.

The dual-flow screen design with 3/8-inch mesh has been used successfully at Big Bend Units 1, 2, and 3 for many years, and, based on testing to date, has the features necessary for the protection of small organisms. The number and size of the screens have been preliminarily determined on the basis of a standard screen face velocity (approach velocity) of 0.5 fps at 0.0 mean low water. This velocity criterion could be changed to a higher value (up to 1.0 fps) if ongoing studies show no significant difference between the velocities being evaluated. Such a change would result in substantial savings in capital and operating costs. Based on the 0.5-fps velocity criterion, six 10-foot-wide screens will be required. Each screen will be submerged to a depth of -21.5 feet. Each of the 42 screen baskets will be equipped with easily replaceable 0.5-millimeter-mesh panels and fish-collection buckets. The fine-mesh screen must be operated continuously to prevent clogging and to limit the time that organisms are impinged. Since continuous operation results in greater wear of the mechanical components than does intermittent operation, as is the case with the existing screens, greater reliability will be achieved through the use of heavy-duty rollers, bushings, bearings, sleeves, chains, and motors. To reduce maintenance requirements further, 3/8-inch-mesh screen panels will be provided for periods of the year when entrainment of meroplankton is not of concern.

Each fine-mesh screen will be capable of operating continuously at speeds of up to 28 feet per minute (fpm). On automatic control, the screen will run continuously at 7 fpm, if ongoing studies continue to indicate that this speed is adequate to protect impinged organisms. As the head differential across the screen reaches 4 inches, and then 6 inches, the speed will automatically increase to 14 and 28 fpm, respectively. Should studies indicate the need for different speeds than these, the controls could be modified to achieve any speed between 0 and 28 fpm.

Each screen will be equipped with a low-pressure (approximately 5-10 pounds per square inch (psi) organism spray wash header on the ascending side and a high-pressure (40 to 60 psi) spray wash header for debris removal on the descending side of the screen. Separate pumps will supply water to each header and will take suction from the fine-screened water downstream of the circulating-water pumps. These nozzles will have 1/2-inch-diameter orifices and will be evenly spaced at 1-foot intervals over the 10-foot header length to ensure a uniform spray pattern across the screen baskets.

Although the low- and high-pressure sprays will wash organisms and debris into separate troughs, all troughs will manifold into a common sluiceway, and the combined flow will pass through a debris trap and a 4-inch-mesh screen. The flow will carry organisms and debris to a release point north of the intake canal via an 18-inch pipe (Figure 4-11). This design will maximize the opportunity for survival of any organisms not removed by the low-pressure spray but subsequently removed by the debris spray.

The organism-return pipe will be sized to achieve a transport velocity in the range of 5 fps. The pipe will run west along the south side of the intake channel to a footbridge, from which it will be supported as it traverses the channel. From this point, the pipe will take one of two possible routes. It will travel either west, north, and east or simply north and east to a channel where it will discharge. While the first route would be longer, it would avoid road crossings, which require buried pipe sections, and thus may be more suitable from a biological and engineering standpoint. The length of the return pipe will range from 1,500 to 4,700 feet, depending on the exact routing and location of discharge in the channel.

To alleviate fouling problems, there will be two pipes. With this arrangement, the flow can be frequently diverted from one pipe to the other, and the unused pipe can be drained and dried. Each pipe will be cleaned with a pressure-driven "pig."

The proposed design involves expanding the Unit 3 operating deck, from which the dual-flow, fine-mesh screens will hang. The design is similar to the existing screen structure installed at Big Bend except for the overall dimensions and number of screens.

As with the existing structure, the expanded operating deck will be supported on piles at an elevation of +9 feet. The channel bottom will be maintained in the screen structure area at the existing depth of -24.5 feet.

Initially, a chain link fence similar to that currently used at Units 1, 2, and 3 to exclude large floating debris will be incorporated into the new screen structure and will extend to a depth of -5 feet. If, in the future, the fence is found to be inadequate to protect the fine-mesh screening medium, provision will be made for installation of stationary bar racks to replace the fence. Such racks would be located approximately 14 feet upstream of the fine-mesh screens. The rack structure would be inclined at a 5:1 slope and would have bar spacings of 1.5 inches. A common, movable rake would raise all debris collected on the bar racks to the operating deck and into a rail-mounted hopper. In the event that trash racks are added, provision will be made for lateral fish passageways at the end of the structure.

Construction will be performed "in the wet" and will consist of excavating, driving necessary piles, and sheeting and fabricating the operating deck. The troughs for the traveling screen assembly and the pumps will then be installed. It may be necessary to shut down Unit 3 during pile driving or equipment installation.

As a part of the conceptual design evaluation, cost estimates were developed for installing fine-mesh screens at Big Bend Units 3 and 4. Costs were also established for a duplicate system that could be installed on Units 1 and 2 if further reduction in entrainment were required. These costs were compared to the differential costs (costs over and above the costs of a conventional once-through system) of a closed-cycle cooling system. Table 4-6 provides a summary of this cost comparison.

The closed-cycle cooling system that was used for comparison is a mechanical-draft cooling tower (Section 3.4.1). An engineering study of closed-cycle heat-rejection systems for Big Bend Unit 4 was performed by the Applicant (Stone & Webster Engineering Corporation 1979). The study results indicate that a mechanical-draft tower would be the preferred closed-cycle system. Such a tower would be of concrete construction and would utilize saltwater as the cooling medium. The conceptual location of a cooling tower is directly south of the Unit 4 plant structure on the southern bank of the discharge canal, just west of the bottom-ash pond and Beach Road. The tower would be located to minimize impact on the nearby mangrove area. Tower costs are based upon a design that will achieve a maximum drift rate of 0.002 percent of the circulating-water flow. Site and foundation preparations costs are included as separate items. Energy requirements and derating penalties are included in the estimated costs. The tower requires 4.5 megawatts of auxiliary power year round and creates a generation loss due to an increased turbine pressure of 2.2 megawatts on both summer peak and annual average bases.

The additional cost required to add a fine-mesh-screen system to Units 3 and 4 is $10,215,000. The cost to retrofit a fine-mesh-screen system to Units 1 and 2 would be approximately $7,985,000. The cost of the two systems is approximately the same; however, the cost of the shared-return system is included in the estimate for Units 3 and 4. The additional cost of providing a mechanical-draft tower is $51,802,000.

4.2.4.2.2 Discharge Structure

Pipes from the condenser will connect to a 9-foot-diameter pipe leading the water to the discharge structure. The Unit 4 discharge structure will resemble those for

Units 1, 2, and 3, shown in Figure 4-10. The warm circulating water from Unit 4 will also exit to the discharge channel. The structure, designed to reduce the velocity of the discharged water, will control erosion of the far bank of the dredged discharge channel. Flow from the Unit 4 discharge structure will combine with the discharge water from the three existing units and move westerly through the channel to the point of discharge to Tampa Bay. Flows in the discharge channel and their respective velocities are presented in Table 4-5. The characteristics of the thermal plume produced by Units 1-4 are described in Section 6.3.3.

4.2.4.2.3 Biocide Additions

As described in Section 4.2.4.1, Big Bend is equipped with one chlorinator to which Unit 4 will be connected. Liquid chlorine will be fed to the Unit 4 cooling water at a similar rate and in the same manner that it is being fed to the existing units.

The chlorine for Unit 4 will be injected for 20 minutes three times a day. Only one unit at a time will be chlorinated. The feed rate is expected to range from 5,000 to 8,000 lb/day, with an average feed rate of 6,000 lb/day. Residual free chlorine in the discharge is expressed as "total residual accidents" and will be limited to 0.2 mg/ℓ.

4.2.5 FLUE-GAS-TREATMENT SYSTEM

4.2.5.1 Overview of Technology Availability

When coal is used to fire the steam generators, three major air pollutants result: sulfur dioxide (SO_2), total suspended particulates (ash and other solid material), also known as particulate matter (PM), and nitrogen oxides (NO_x). These pollutants are released to the atmosphere through the plant's chimneys. The amount of these pollutants that can be so released is regulated by both Federal and State laws described in this document. The amount of these pollutants emitted as a result of burning coal in an electricity-generating unit depends on the sulfur and ash content of the coal being burned and on the load factor of the unit (i.e., the percentage of design capacity at which a unit is operating, which typically varies from 25 to 100 percent).

The regulation of air pollutant emissions from a plant is based on the maximum amount of air pollutants that would be produced under the following conditions:

- The coal being burned contains the highest sulfur content that could be expected in the type of coal that the Applicant has (or will have) contracted to buy for the unit.
- All four generating units at Big Bend are in operation.
- The unit is operating at design (100 percent) capacity.

The Applicant intends to burn Midwestern bituminous coal in its proposed Big Bend Unit 4. The flue-gas-treatment systems are to be designed for coals containing up to 6 lb/10^6 Btu of SO_2 and 13.5 percent ash (as fired).

In order to keep the amount of air pollutants released by the plant in conformity with state and Federal regulations, the Applicant must use devices to control the SO_2, particulates, and nitrogen dioxide (NO_2) that would otherwise be released in the burning of coal in the plant. Devices to control the SO_2 are called scrubbers. A variety of devices are available to remove the particulates. Nitrogen dioxide is controlled by the design of the steam generator. Each of these control devices/methods is available in several different designs. The designs, and their advantages and disadvantages, are summarized in Table 3-15.

The Applicant proposes to use a wet limestone scrubbing system and electrostatic precipitators in its gas-cleaning system for Big Bend Unit 4. The type of NO_x control system to be used in the plant will be determined by the boiler manufacturer.

4.2.5.2 Coal Fuel

Unit 4 will fire medium- to high-sulfur Midwestern bituminous coal. Several coals have been under consideration. The proximate and ultimate analyses of each of the alternative coals still under consideration for Unit 4 are presented in Table 4-7, together with physical characteristics of these coals. Also presented is the fuel rate, which is based on the heating value of the coal and boiler performance characteristics.

For the purposes of the air pollution control evaluation and specification of control equipment, analyses of the physical and chemical characteristics of three design coals were performed. The design coals included in Table 4-7 were regarded as representative of the above fuels. Coal F-1A was used in the specification of the primary particulate control device; coals F-2A and F-2B have been used for the specification of the flue-gas-desulfurization (FGD) system.

4.2.5.3 Arrangement of Flue-Gas-Treatment System

For a schematic diagram of the flue-gas combustion and treatment system, see Figure 4-12.

4.2.5.4 Selection of Flue-Gas Treatment

The air pollution control techniques and systems that are incorporated in the facility design for emission control are described below:

- Formation of NO_x (as well as carbon monoxide) during combustion will be inhibited by proper operation and design of the boiler and the combustion air control system.
- Particulate matter will be controlled by an electrostatic precipitator installed at the exit of the air preheater.
- SO_2 emissions will be minimized by a combination of coal washing and flue-gas scrubbing, the latter by means of an FGD system.

4.2.5.4.1 NO_x Control

The emission of NO_x from the combustion system will be minimized by the design of the burners and boiler to be provided by the boiler manufacturer, Combustion Engineering, Inc. (CE). The balance-draft boiler with a tangentially fired furnace to be supplied has a demonstrated capability of limiting NO_x formation from the firing of bituminous coal to 0.6 lb/10^6 Btu as NO_2. This meets the applicable new source performance standard (NSPS). The EPA has certified several CE boilers now in operation as capable of meeting the NSPS, but these boilers were neither designed nor guaranteed to limit NO_x emission to these levels.

The formation of thermally produced NO_x is inhibited in the CE boiler by off-stoichiometric combustion, that is, by operation of the burners with a fuel-rich fuel/air mixture. This is accomplished by two techniques: biased firing and two-stage combustion. The former technique consists of operating some burners at fuel-rich mixtures and others at lean mixtures. Initial combustion in fuel-rich burners then occurs in a chemically reducing atmosphere, followed by complete combustion after substantial heat dissipation. The resultant lower flame in all burners inhibits the formation of thermal NO_x. The latter technique, two-stage combustion, is accomplished by diverting a portion of the combustion air to over-fire air ports located above the burners. Fuel-rich combustion takes place with the attendant heat loss, followed by complete mixing and combustion utilizing the balance of combustion air above the primary combustion zone. CE has incorporated over-fire air ports in the boiler design. Operation of these ports has been found to be unnecessary below 90 percent maximum combustion rating (MCR). Two-stage combustion may be unnecessary but will be employed should monitoring indicate that the NO_x emissions may exceed standards. The NO_x emission limitation is equivalent to an emission rate of 2,598 lb/hr (as NO_2) at full-rate load.

Compliance with the NSPS for NO_x will be demonstrated in appropriate tests. A system for continuously monitoring NO_x emissions will be installed, calibrated, maintained, and operated at a point downstream of the economizer outlet.

4.2.5.4.2 Control of Particulate Emissions

Particulate matter (PM) emissions (fly ash) from the combustion system will be controlled by means of an electrostatic precipitator (ESP). This type of control device has received the widest application on coal-fired utility boilers and is capable of ensuring compliance with the applicable NSPS for outlet grain loading when firing medium-sulfur coal.

The completed specification for the Unit 4 ESP requires the manufacturer to guarantee an outlet PM emission of 0.03 lb/10^6 Btu and 20 percent opacity, which matches the applicable NSPS for electric utility steam-generating units. Accordingly, the collection efficiency will be a minimum of 99.7 percent. The design and performance requirements for the ESP are based on the use of coal F-1A (Table 4-7).

The ESP will be of a rigid-frame European design and will be installed at the outlet of the air preheater and before the inlet to the induced-draft (ID) fans. Appropriate ESP compliance tests will be conducted. A continuous monitoring system for opacity will be installed, calibrated, maintained, and operated at a point in the flue-gas system downstream of the ESP. The guaranteed particulate loading/emission rate must be verified in two performance tests. The first test is to be performed within 90 days after the start of commercial operation and the second within 12 months of the first successful performance test. Should the ESP test results fail to comply with the guaranteed PM emission rate, the manufacturer must modify the initial installation to meet the performance requirements.

The specification for the ESP requires the vendor to guarantee the outlet grain loading for all coals under consideration for firing in Unit 4. Coal F-1A was used in the discharge calculations to provide a conservatively high estimate of each parameter. With coal F-1A, the precipitators will operate at 99.7 percent efficiency, removing about 50,000 lb/hr of fly ash. A balance of 130 lb/hr of fly ash will escape the precipitators, entraining in the flue gas. These calculations were based on the following assumptions:

- No ash is removed during crushing or pulverization of the coal.
- The quantity of unburned carbon in the total particulate grain loading is negligible.
- Twenty percent of the ash introduced to the boiler is discharged as bottom ash, while 80 percent is entrained in the flue gas as fly ash.
- The outlet particulate loading from the ESP is 0.03 lb/10^6 Btu.

4.2.5.4.3 SO_2 Removal

4.2.5.4.3.1 Coal Washing

An SO_2 washing credit for coal pretreatment is permitted to meet the percentage SO_2 reduction requirements of the applicable NSPS. It is thereby expected that, with raw coal sulfur levels equal to or greater than 3 lb/10^6 Btu (but no greater than 6 lb/10^6 Btu), the overall SO_2 removal requirement of 90 percent prescribed by the applicable NSPS will be achieved through a combination of 25 percent removal (on a lb/10^6 Btu basis) in washing, 5 percent retention in the ash from fired sulfur, and 86 percent removal in flue-gas cleaning.

4.2.5.4.3.2 Flue-Gas Desulfurization

The SO_2 emissions from the combustion system will be controlled by means of an FGD system. The type of FGD system selected for Unit 4 is a two-stage forced oxidized limestone nonregenerable system capable of removal efficiency of 85-90 percent. A generic description of the FGD process is given in Figure 4-13. In this system, flue gas exiting the induced-draft fans is ducted to the inlet plenum of the FGD booster fans, from which the flow is distributed to three scrubber modules. The booster fans are required to compensate for the pressure drop across the FGD system ranging from 7 to 13 inches water gauge. The flue gases then enter the quencher, where the steam is concurrently scrubbed with a low pH limestone slurry to cool the gas to its adiabatic saturation temperature of approximately 125°F and to remove some SO_2. The flue gases are then passed through to the absorber section (a combination spray tower/packed tower), where the SO_2 is contacted by a high-pH recirculating slurry containing calcium salts. After passing through the absorber, the gases pass through a mist eliminator (a chevron type) upon which entrained droplets are deposited and thus removed from the gas stream. A reheat is provided by mixing the flue gas at about 125°F with ambient air heated to approximately 270°F by fourth-point turbine-extraction steam. Additional stack-gas reheat may be provided by stack gases from Unit 3 at the entrance to the common flue stack.

Limestone ($CaCO_3$) is crushed to about 70 percent through 200 mesh and then slurried to the absorber feed tank, where it contacts the recirculated scrubbing slurry.

Dissolved $CaCO_3$ reacts with sulfite and sulfate ions to precipitate calcium sulfite and calcium sulfate solids.

Internal to the FGD system, the quencher recirculation loop operates at sufficiently low pH to permit forced oxidation by compressed air supply that converts the calcium sulfite solids ($CaSO_3 \cdot 1/2H_2O$) to the form of $CaSO_4 \cdot 2H_2O$ (gypsum). This slurry stream, which contains approximately 10 percent suspended solids, is then pumped to a bank of liquid cyclones, where it is dewatered to 35 percent solids. These thickened solids are pumped from the thickener underflow to the vacuum filters, where they are dewatered and washed, yielding a cake that is approximately 90 percent solids.*

It is anticipated that the bulk of chlorides entering the FGD system will be withdrawn from the vacuum filter wash as a brackish or saline liquid effluent with a chloride concentration not exceeding 45,000 parts per million. After appropriate treatment, this effluent will be discharged to Tampa Bay.

Scrubbers operating at 86 percent efficiency with delivered coal containing 3.0 lb/10^6 Btu of sulfur will remove 15,900 lb/hr of SO_2, leaving not more than 2,592 lb/hr as a gaseous constituent of the wet flue gas.

Appropriate FGD compliance tests and applicable fuel analyses of both the raw and received coals will be conducted to determine potential SO_2 emissions and the degree of SO_2 removal required at the power plant. A system for continuous monitoring of SO_2 emissions will be installed, calibrated, maintained, and operated at a point downstream of the FGD system.

4.2.5.5 Influences on Flue-Gas Composition Incidental to SO_2 Scrubbing

The interaction of the wet reactant slurry and the wet flue gas in the scrubber has three other coincidental effects on flue-gas composition:

- Some additional fly ash removal is effected. Credit for this removal is not taken into account in the computations of effluents because the amount of fly ash in flue gas entering the SO_2 scrubber is minimal, and because particulate matter is added to the flue gas by the scrubbers due to a carryover of scrubbing slurry.
- Water vapor formed from the slurry is added to the flue gas during adiabatic water saturation of the scrubber inlet gas.
- A small amount of NO_x is removed by the wet scrubbers.

4.2.5.6 Stack Discharge

After leaving the scrubber, flue gases are routed to the chimney for disposal. The flue gas from Unit 4 will have a 1,778,000 actual cubic-feet-per-minute (ACFM) flow rate calculated at 156°F gas temperature, and it will have a stack velocity of 65 ft/s when only Unit 4 is discharging into the common stack serving Units 3 and 4.

The existing stack on the Big Bend site will serve both Unit 3 and Unit 4. The height of that stack is 490 feet, which is in conformity with EPA criteria for good engineering practice (44 FR 9, January 12, 1979).

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*The gypsum crystals thus formed are of the size required to meet quality specifications for the manufacture of commercial wallboard, and current TECO plans call for marketing the by-product for that purpose.

The building housing Unit 4 will be approximately 264 feet in height, exceeding by 60 feet the height of the tallest existing building (204 feet) on the site.

4.2.6 PLANT SOLID-WASTE SYSTEM

4.2.6.1 Introduction

Operation of the proposed Big Bend Unit 4 will result in the production of two kinds of solid waste: precipitated SO_2 catch from the wet limestone SO_2 removal system and ash from coal combustion.

Precipitated calcium/sulfur chemical solids are produced when SO_2 is removed from the steam generator's exhaust (flue gas) using limestone as reagent. The solids are precipitated during the reaction between the limestone slurry feed and the SO_2 dissolved in the scrubber outlet liquid. These solids and any unused solid portion of the limestone slurry feed are dewatered to a cake consistency.

Ash, a noncombustible component of coal, is produced when coal is burned in the steam generator furnace. Two kinds of ash result when the coal is burned: "bottom" ash and "fly" ash. Bottom ash, which has a larger particle size than fly ash, falls to the bottom of the boiler furnace during the combustion process. Fly ash, which is fine particulate matter, leaves the furnace with the flue gases and is collected by the electrostatic precipitators.

The amount of these solids that will be generated by the proposed plant is determined by the following factors:

- The amount of ash and sulfur in the fired coal
- The SO_2 removal efficiency of the scrubber
- The capacity factor/coal-use rate of the plant, or the number of hours (per year) of plant operation at a given percentage of capacity and level of coal impurities (the higher these numbers, the greater the quantity of solid waste)

Additionally, minor quantities of pyrites (metallic sulfides rejected from the pulverizer mills) and water-treatment-waste solids contribute to the solid waste generated by the plant. Water-treatment solids are precipitated by chemical reaction or clarification as the wastewater is processed for reuse in the plant.

4.2.6.2 Solid-Waste Production

Solid wastes resulting from Unit 4 operation will include bottom ash, economizer ash, pyrites, fly ash, and flue-gas-desulfurization (FGD) by-product (Table 4-8).

Bottom ash will be collected in a water-filled bottom-ash hopper and hydraulically sluiced to an ash pond. The bottom-ash disposal pond will be located in the area concurrently occupied by an unused U-shaped cooling pond. This area is shown in Figure 4-3. The conceptual layout of the area is shown in Figure 4-14. The bottom ash will be sluiced from the plant to either of two earthen-dike primary settling ponds. Overflow from the primary settling ponds will flow by gravity to a secondary settling pond. Clarified water will then be pumped back to the plant, completing the recirculation system. The major portion of the bottom ash will settle within the primary settling ponds. Once these ponds are filled, the ash will be hydraulically dredged to a final disposal cell. These cells will be developed as disposal volume dictates. The cells will be formed by earthen dikes. It is expected that the disposal cells will reach a maximum height of 35 feet. The settling ponds will be designed to store approximately 6 months of ash production between dredgings. This disposal site will be designed and operated in accordance with restrictions of the Resource Conservation and Recovery Act on construction of solid-waste disposal sites in flood plains (44 FR 4,356, September 13, 1979). The estimated quantity of bottom ash produced is 25,680 ton/yr (Table 4-9). Pyrites removed from the coal prior to combustion, economizer ash, and fly ash will be sluiced to a fly-ash pond as shown in Figure 4-14.

Unit 4 fly ash will be removed from the flue gas by electrostatic precipitation and collected in hoppers. Fly ash from Units 1, 2, and 3 is currently collected and pneumatically transported to silos for storage and subsequent sale as a raw material in the production of portland cement. These same provisions will be included for Unit 4. Where fly ash is consumed solely for the production of cement, its utilization rate is directly related to the level of construction activity and thus to the economic viability of the region. A downturn in the economy may result in the need for onsite disposal. In addition, the increasing coal-fired electric power generation in Florida may cause an overabundance of fly ash on the market. To guard against a decrease in fly-ash demand, which could jeopardize the dependability of the unit, provisions for the disposal of fly ash from Unit 4 have been made. At times when it may be impossible to market Unit 4 fly ash, the ash-disposal pond will be utilized. The conceptual layout of the fly-ash disposal area is shown in Figure 4-14. The solids will be sluiced from the plant to either of two lined primary settling ponds. Overflow from these ponds will be transported by gravity to a lined secondary settling pond. Clarified water will be pumped back to the plant, completing the recirculation system. The rate at which these settling ponds fill with solids will depend upon the viability of the fly-ash market. When the ponds reach the point at which they must be cleaned, a final earthen-dike disposal cell will be constructed and lined. The ash will be hydraulically dredged to the disposal cell. The area to the south will be reserved for future disposal cells, as needed.

The FGD system will utilize a two-stage, forced oxidation, limestone, wet-scrubbing process. The resulting FGD by-product will consist mainly of calcium sulfate (gypsum). The FGD by-product will be handled and stored in an area south of the Unit 4 ash pond. This facility is discussed in Section 4.2.6.3. The estimated annual by-product production is 210,000 tons. It is expected that the gypsum will be of sufficient purity to be used as a raw material in the manufacture of drywall.

4.2.6.3 FGD System By-Product Storage/Disposal Area

The selected FGD system will utilize an adaptation of the limestone-scrubbing process that will produce high-quality, coarse-grained chemical gypsum as a specification-grade by-product. The FGD gypsum has the following advantages over the by-products/wastes produced by other FGD systems:

- Good dewatering properties due to the blocky and elongated nature of the calcium sulfate crystals
- Potential for utilization as an industrial raw material
- Good structural properties for land-based storage/disposal
- Minimal chemical oxygen demand of leachate from stored waste

FGD gypsum is considered to have greater potential for product sales/utilization than any other possible by-product of the limestone-slurry-scrubbing system. Such material has been successfully used in the production of wallboard, in cement manufacturing as a set retarder, and in agriculture as a soil additive.

The existence of major wallboard manufacturing activity in Florida suggests that the FGD gypsum is a marketable product. If indeed a market is established, the gypsum produced by Unit 4 will be sold. However, the unpredictability of a newly emerging FGD gypsum market in the United States and the general uncertainty of the national economy combine to make long-range planning uncertain for by-product gypsum management.

In an effort to deal with this uncertainty, the Applicant has developed a multiphase storage/disposal plan involving the successive use of four adjoining storage areas. The purpose of this plan is twofold:

1. To provide a means of by-product gypsum storage during periods of low gypsum demand, thus preventing interruption in plant operation

2. To provide calendar time for later establishment of a long-range plan for the disposal of gypsum from Unit 4 should a sustained market fail to materialize

The proposed FGD solids storage/disposal site is located south and southeast of Big Bend Station. Figure 4-15 shows the four gypsum storage/disposal areas to be utilized when and as needed. The total site area is 97 acres. The area was previously cultivated land and pasture and is currently zoned for industrial use. The area was chosen in order to ensure the preservation of Newman Branch and related wetlands.

Plans for the storage/disposal of FGD gypsum call for successive use of the four separate land areas indicated. A new area will be developed only when an area in service has been utilized to almost its full storage capacity. This program provides for long-term disposal if needed, while serving as a means of gypsum storage through short-term disposal. Use of the comparatively small disposal areas shown in Figure 4-15 will allow for good control of rainfall runoff and of housekeeping operations if substantial quantities of by-product gypsum should accumulate due to lack of sales.

Project plans also call for the gypsum to be transported to the storage/disposal site by means of a conveyor system and to be handled subsequently by bulldozer. If substantial gypsum storage proves necessary, a landfill will be created using the heaped-fill configuration shown in Figure 4-16. This technique is deemed to be the most adequate in view of the geological and topographical characteristics of the site.

Past experience with coarse-grained materials in this type of landfill demonstrates that problems arising in the areas of groundwater pollution, slope stability, and site preparation are minimal in comparison with other disposal methods. Fugitive dust problems are not expected because the gypsum, when left undisturbed, forms a protective crust with a minimum of wind erosion and dusting tendencies.

In order to contain the FGD system by-product material, berms will be constructed around the entire area. These berms will be designed to withstand a 100-year flood and storm surge. Storm water falling within the bermed area will be directed to temporary storm-water storage in that area. It will then be allowed to percolate into the ground. Through the design and placement of dikes around the disposal areas, the integrity of Newman Creek and adjacent wetlands will be protected from any potential discharge of runoff.

4.2.7 DOCK FACILITIES

Existing Units 1, 2, and 3 burn coal that is delivered to the site by covered barge, and the same will be true of Unit 4. Barge access to the site is provided by a dredged ship channel parallel to the western edge of the dredged site land, as shown in Figure 4-3. A dock is located adjacent to the ship channel to provide for barge mooring and to serve as a platform for the barge-loading and coal-conveying equipment. Fuel-handling facilities are described in Section 4.2.8. The ship channel and dock serve only the Big Bend generating units. No modifications to the dock or to the unloading facilities are contemplated in connection with construction of Unit 4.

4.2.8 FUEL-HANDLING AND STORAGE FACILITIES

Coal to fuel the proposed Unit 4 will be received, stored, and handled in the same manner and by the same facilities now used to handle coal for Units 1, 2, and 3; no new facilities will be required. The facilities, shown in Figure 4-3, include a barge unloader, conveyors, and a stacker/reclaimer.

Figure 4-17 is a schematic of the route the coal takes. It is unloaded from the barges by a dock-mounted 4,000 tons per hour (tph) ladder unloader. The coal is then transported south along the dock via a 72-inch conveyor belt to Transfer Tower 1 and then east to Transfer Tower 2. At Transfer Tower 2 the coal may either be piled as emergency storage or continue east on the 72-inch belt to a stacker/reclaimer. At the stacker/reclaimer, the coal may either continue on the conveyor belt to Transfer Tower 3 or may be stacked onto the storage piles. Tower 3 receives coal from the stacker/reclaimer and transfers it to two 54-inch covered conveyors leading to the fuel bunkers within the plant. All transfer points are enclosed.

The coal-storage pile north of the stacker/reclaimer is 1,800 by 250 feet and is capable of storing 435,000 tons. The coal-storage pile south of the stacker/reclaimer is 1,800 by 200 feet and can store 238,000 tons (Figure 4-3). Bulldozers are used to distribute the coal within the piles efficiently.

The total annual fuel requirement for Unit 4 is estimated to be 950,000 tons and the annual requirement for all four units is estimated to be 3,400,000 tons. An average shipment contains about 25,000 metric tons of coal. The maximum transfer rate of coal is 4,000 tph. The additional barge traffic required to supply fuel for Unit 4 will amount to less than one delivery per week.

4.2.9 TRANSMISSION FACILITIES

One 230-kilovolt circuit having a length of 2,970 feet (9/16 mile) will connect Big Bend Unit 4 to the existing Big Bend substation. Electric power generated by the unit will enter the existing TECO transmission system at that point. The new transmission circuit will utilize existing towers and the existing transmission route between the plant and the substation.

Routing of transmission lines from Units 1, 2, and 3 and proposed Unit 4 is northward from the plant buildings across the intake canal, then east for about 1,000 feet, and then approximately east-southeast to the substation.

There are two existing sets of steel towers, one for the transmission circuits from Units 1 and 2 and the other for the existing Unit 3 circuit and the Unit 4 circuit to be added.

Addition of the circuit for Unit 4 will require no additional land for the transmission route, nor will it require additional clearing of vegetation and trees or changes in topography. There will be no impact on sensitive areas or landmarks.

4.2.10 ATMOSPHERIC EMISSIONS

4.2.10.1 Regulatory Emission Requirements

The Big Bend Station presently consists of three coal-fired units, having a total nameplate rating of 1,336.5 megawatts and a net continuous rating of 1,062 megawatts. Units 1 and 2 discharge flue gases via a 490-foot common-flue stack and Unit 3 is served by an identical stack, which is designed to accommodate another unit. Emissions from the existing units at Big Bend Station are limited by the Florida Air Pollution Rules (APR; Florida Department of Environmental Regulation 1979), as revised in June 1979. Prior to the revisions, sulfur dioxide (SO_2) emissions were limited to a maximum 2-hour average of 6.5 lb/10^6 Btu, and emission limitations for all three units were limited to a 3-hour average of 35 tph and a 24-hour average of 32 tph. The emission limitations were subsequently revised to 31.5 tph as a 3-hour average and 25 tph as a 24-hour average. The emission of particulate matter may not exceed 0.1 lb/10^6 Btu heat input from each of the three units. Unit 3 is limited to an emission of 0.7 lb/10^6 Btu of nitrogen oxides (NO_x). The operating and emission parameters of Units 1, 2, and 3 at full load are documented in Table 4-10.

The proposed Unit 4 will be fired with medium-sulfur bituminous coal and will have a continuous rating of 425 megawatts. The regulations and guidelines that govern the control of air pollutant emissions from a source such as Unit 4 are the new stationary sources performance standard (NSPS), electric utility steam-generating units (40 CFR 60, 1979; 40 FR 33580, June 11, 1979), the Florida State Implementation Plan (SIP) and air pollution rules (APR, Florida Department of Environmental Regulation 1979), the best available control technology (BACT) provisions of the prevention of significant air quality deterioration (PSD) regulations (40 CFR 51, 1978; 43 FR 26380, June 19, 1978), the lowest achievable emission rate (LAER) provision of the nonattainment area requirements (40 CFR 51, Appendix S, 1979; 44 FR 3274, January 16, 1979), and national emission standards for hazardous air pollutants (NESHAP; 40 CFR 61, 1978). The following is a discussion of these regulations and guidelines and of their applicability to TECO's proposed Big Bend Station Unit 4.

4.2.10.1.1 New Stationary Sources Performance Standard

The NSPS is a set of national emission standards for stationary sources of air pollution. These standards are applicable to specific categories of sources and apply not only to new sources but also to modified or reconstructed sources of air pollution. For fossil-fuel-fired stationary sources, the Clean Air Act Amendments (CAAA) mandate that the NSPS include both a standard establishing specific emission limitations and a standard requiring achievement of a percentage reduction in the emissions that would have resulted from the use of fuels not subject to treatment before combustion. The original NSPS were promulgated in December 1971 (40 CFR 60, Subpart D) and these were revised for electric utility steam-generating units on June 11, 1979 (40 CFR 60, Subpart Da). The latter standards apply to utility boilers firing more than 250 x 10^6 Btu/hr heat input of fossil fuel for which construction started after September 18, 1978.

The NSPS for electric utility boilers include emission standards for particulate matter (PM), SO_2, and NO_x. The emission limitations and required percentage reductions for these pollutants applicable to Big Bend Unit 4 are summarized in Table 4-11. The compliance provisions of the NSPS are also presented in this table.

For boilers firing bituminous coal, the SO_2 emissions into the atmosphere are limited to 1.20 lb/10^6 Btu heat input, and a 90 percent reduction in potential SO_2 emissions is required except when emissions into the atmosphere are less than 0.60 lb/10^6 Btu. When SO_2 emissions are less than 0.60 lb/10^6 Btu, a 70 percent reduction in potential emissions is required. Compliance with both the emissions limitations and required emission reduction is to be determined by continuous monitoring that produces a 30-day rolling average. The percentage reduction is based on the overall SO_2 removal by flue-gas desulfurization (FGD), coal washing, coal pulverization, and sulfur retention in fly ash and bottom ash. The SO_2 standard is presented as a graph in Figure 4-18.

The PM standard limits emissions to 0.03 lb/10^6 Btu heat input and requires a 99 percent reduction in potential emissions from coal-fired boilers. Compliance with the emission limitation for PM is deemed to ensure compliance with the percentage reduction requirements. The PM standard also limits opacity to 20 percent on a 6-minute average with the exception of one 6-minute period per hour when opacity is limited to 27 percent.

The NO_x emission standard restricts boilers firing bituminous coal to 0.60 lb/10^6 Btu heat input and requires a 65 percent reduction in potential NO_x emissions. Again, compliance with the allowable emission limitation satisfies the percentage reduction requirements of the standard. Continuous monitors are required for measuring the emission of NO_x, and compliance with the standard is based on a 30-day rolling average.

4.2.10.1.2 The Florida State SIP and APR

Under Section 17-2.05 of the Florida APR, as amended June 29, 1979, fossil fuel steam-generating plants of 250 million Btu/hr heat input or greater are required to meet emission limitations for PM, SO_2, NO_x, and opacity. The emission limitations required for the Big Bend Unit 4 are summarized in Table 4-12. For new solid fossil fuel steam-generating plants, the SO_2 emissions are limited to 1.2 lb/10^6 Btu heat input, PM emissions to 0.1 lb/10^6 Btu heat input, NO_x emissions to 0.7 lb/10^6 Btu heat input, and visible emissions to Number 1 of the Ringelmann Chart or 20-percent opacity.

BACT evaluation is also required for those major pollution sources undergoing State PSD review under Section 17.2.03 of the Florida APR. This evaluation is the same as the U.S. Environmental Protection Agency (EPA) BACT evaluation, which is detailed in the following discussion.

4.2.10.1.3 Best Available Control Technology

The basic control technology requirement of the PSD regulations is BACT, which is defined as follows:

> An emission limitation... based on the maximum degree of reduction for each pollutant... which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-

> by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable... for control of such pollutant.

Major sources are exempt from BACT requirements for a given pollutant if the increase in allowable emissions for that pollutant is less than 50 tons/yr, 1,000 lb/d, or 100 lb/h, whichever is most restrictive.

BACT requirements (U.S. Environmental Protection Agency 1978) are intended to ensure that the control systems incorporated in the design of a proposed facility reflect the latest in control techniques used in a particular industry and take into consideration existing air quality in the vicinity of the proposed facility. Because the NSPS for electric utility steam generators were promulgated June 11, 1979, and the associated cost-benefit analyses were performed just before that date, compliance with these standards may indeed be considered application of BACT in the utility industry. Notwithstanding this, an evaluation of the air pollution control techniques and systems is required, including a cost-benefit analysis of alternative control technologies capable of achieving a higher degree of emission reduction. The cost-benefit analysis requires documentation of the materials, energy, and economic penalties associated with the proposed and alternative control systems as well as the environmental benefits derived from these systems.

4.2.10.1.4 Lowest Achievable Emission Rate

The control technology requirement specified for sources located in or having an impact on a nonattainment area is LAER.

However, since the Big Bend Station is not located in, nor does it impact significantly on, a nonattainment area for any of the criteria pollutants, LAER is not required for any pollutant emission from the proposed Unit 4.

4.2.10.1.5 National Emission Standards for Hazardous Air Pollutants

Section 112 of the CAAA requires the EPA to publish a list, to be periodically revised, that includes hazardous air pollutants for which NESHAP would be developed. To date, the NESHAP do not affect the design or operation of the proposed Big Bend Station Unit 4.

4.2.10.2 Emissions

The Unit 4 boiler is considered a major source of PM, SO_2, NO_x, and carbon monoxide (CO).

The receiving, handling, and storage of coal for Unit 4 is an additional source of both controlled and fugitive particulate emissions. Similarly, the limestone required for the FGD system is a potential source of fugitive particulate emissions. The principal air pollution control systems and techniques incorporated in the facility design and operating and maintenance procedures are itemized below:

- PM emissions from the boiler will be controlled by an electrostatic precipitator (ESP) installed at the exit of the air preheater.

- SO_2 emissions will be minimized through a combination of coal washing and tail-gas cleaning by means of an FGD system (in compliance with the NSPS).

- NO_x and CO formation during combustion will be inhibited by the proper operation and design of the CE balance-draft boiler with tangentially fired furnace and combustion-air control system.

- Fugitive dust emissions resulting from the receiving, handling, and storage of coal and limestone will be minimized by a combination of techniques, including control of the surface moisture content of coal in storage piles; control of the particle size of limestone; containment and control of conveyors, transfer points, and crushing equipment; and the proper maintenance of coal- and limestone-handling facilities.

For a more detailed description of these control techniques and systems see Sections 4.2.5 and 4.2.8. Detailed documentation for compliance with NSPS and determination of BACT are also presented in these sections.

4.2.10.2.1 Stack Emissions

The stack emissions for the proposed Big Bend Unit 4 at full load are presented in Table 4-13, and the full load boiler performance data are presented in Table 4-14. Emissions were determined using the generic and actual engineering data for the air pollution control equipment and boiler design for Unit 4. The PM emissions from the boiler will be controlled by an ESP with a design specification of 0.03 lb/10^6 Btu and 20 percent opacity, in compliance with the NSPS for coal-fired electric power-generating units and FAPR for solid fossil fuel steam generators. This results in a PM emission of 129.9 lb/hr. The NO_x emission from the boiler will be controlled by the design of the burners and boiler. The tangentially fired boiler will have a design specification of 0.60 lb/10^6 Btu and NO_x emissions of 2,598 lb/hr. The SO_2 emissions from the boiler are controlled by a combination of coal washing and tail-gas scrubbing using an FGD system. The coal-washing and limestone FGD system is specified for a reduction of potential SO_2 emissions of 90 percent for raw coals having a sulfur content ranging from 3.0 to 6.0 lb/10^6 Btu. The SO_2 emission therefore ranges from 2,592 to 5,184 lb/hr depending upon the sulfur content of the coal. The emissions of CO and hydrocarbons (HC) are not controlled by Federal or State regulations. CO emissions were determined using an EPA emission factor (U.S. Environmental Protection Agency 1977a) of 0.057 lb/10^6 Btu. HC emissions were determined using the EPA-recommended emission factor (Neligan 1978) of 0.0005 lb/10^6 Btu. The resulting emissions for CO and HC are 245.7 and 2.1 lb/hr, respectively. The emissions from the proposed Big Bend Unit 4 meet all the Federal and State emission requirements.

4.2.10.2.2 Material-Handling Emissions

Coal to fire the proposed Big Bend Unit 4 will be brought in by barge and routed through the existing barge-unloading, transfer/conveying, and storage pile systems that service Units 1, 2, and 3. Unit 4 will require approximately 951,000 ton/yr of additional coal supplies.

Figure 4-17 is a schematic of the route the additional coal will take at Big Bend. Emission sources are identified by number, corresponding to the emission summary of Table 4-15. The coal barge is first unloaded by means of a bucket unloader. The bucket-unloading mechanism is lowered into the hold of the ship as needed to establish contact with the coal stockpile. The coal is conveyed through a number of transfer points until it reaches Transfer Tower 1. The coal is then further conveyed through Transfer Tower 2 to the stacker/reclaimer. One transfer point exists within the stacker/reclaimer.

The stacker/reclaimer, which is movable along the entire length of the storage area, then loads the coal onto the storage pile. The stacker/reclaimer is adjustable to allow for short drop distances and easy loading and unloading of piles of any height. Heavy machinery is utilized along with the stacker/reclaimer to efficiently distribute the coal within the piles.

Coal is unloaded from the storage piles by means of the stacker/reclaimer. It is then transferred through a surge hopper and an intermediate transfer point to Transfer Tower 3. From this point it is loaded onto a surge pile. The surge pile is unloaded from below by gravity feed conveyors, and the coal is then conveyed to the coal bunkers in the boiler building.

The maximum transfer rate of coal along any leg of the system is 4,000 tph. Because the stacker/reclaimer both loads and unloads the coal storage pile, both operations cannot be conducted simultaneously.

Potential (uncontrolled) and controlled fugitive emissions from the operations of the coal-handling system were estimated with the aid of the EPA technical guidance document (U.S. Environmental Protection Agency 1977b).

Section 2.1.2 of the technical guidance document presents an uncontrolled emission factor for barge loading of coal of 0.4 lb/ton. Because this factor is the only factor presented for coal, it was assumed that unloading emissions would be similar to loading emissions, and the 0.4 lb/ton factor was utilized.

Section 2.1.1 of the technical guidance document presents transfer/conveying uncontrolled emission factors. For coal, a range of 0.04-0.96 lb/ton is given. The geometric mean of this range (0.20 lb/ton) was chosen as the emission factor.

Section 2.6 of the technical guidance document provides a specific emission factor for coal storage piles. The figure given is 0.054 lb/ton, but this does not include loading and unloading emissions, which, according to Section 2.1.4, constitute 27 percent of total emissions. The incorporation of emissions from these operations yielded an estimate of total uncontrolled emissions from the coal storage piles of 0.074 lb/ton.

Visual inspection of the coal-handling facilities at Big Bend were conducted in order to develop control efficiencies. Coal brought in by barge is normally saturated with water and remains saturated in the hold of the barge. Based on the saturated nature of the coal at unloading and on results of the visual inspection, a control efficiency of 90 percent was assumed for this stage at coal handling.

All transfer points within the coal-handling facility are enclosed. While not all of the conveyors are covered, it is assumed that the majority of transfer/conveying emissions are generated at the transfer points and not from belt conveying. Section 2.6 of the technical guidance document, in Table 2-44, presents a control efficiency of 90-99 percent for the enclosing of conveyors and transfer points. For the Big Bend operation, an estimated control efficiency was based in part on visual observation. In view of the moisture content of the coal and the use of enclosure, the control efficiency was estimated to be 95 percent.

Section 2.1.4 of the technical guidance document, dealing with storage piles, presented control efficiencies for the various operations encountered within storage piles. These include the loading of coal onto piles, vehicular movement within piles, wind erosion, and loadout. For coal storage piles the controls and efficiencies presented in Table 4-16 are applicable.

The stacker/reclaimer can be adjusted to any height to minimize the fall distance of the coal onto the pile. Watering by truck is performed in the area of the pile whenever conditions warrant this action. The midpoint of stacker/reclaimer efficiency, 25-50 percent, was utilized. The overall resulting control efficiency for the storage piles is 34.6 percent.

For the surge pile, loadout emissions are controlled by means of gravity feed onto an underground conveyor. The result is an 80 percent reduction in loadout emissions and an overall control efficiency of 12 percent for the surge pile.

Fugitive dust emissions due to coal handling for TECO Big Bend Unit 4 are presented in Table 4-15. Each emission point is shown, together with its potential emissions, control efficiency, and controlled emissions. Calculations are based upon utilization of 951,000 ton/yr in the proposed Unit 4. Estimated uncontrolled emissions are about 900 ton/yr and controlled emissions are estimated at about 120 ton/yr.

It should be kept in mind that the factors used to estimate coal-dust emissions have a very low reliability factor. Because of the great uncertainties involved in deriving and applying emission factors and control efficiencies to fugitive-dust-generating processes, such estimates may be in error by one order of magnitude or greater.

The proposed SO_2-removal systems will necessitate the onsite handling, transfer, and storage of limestone. These operations potentially release PM, the emission of which will be minimized by state-of-the-art control techniques.

The primary method for receiving the limestone will be bottom-hopper railcars and/or dump trucks. A car dump facility will be provided at the unloading point.

In the car dump facility, the limestone will flow by gravity from the car to hoppers to underground belt feeders. It will then be transported by a totally enclosed tubular conveyor to the limestone storage pile, from which it will be discharged through a telescoping chute.

The car dump facility will have an exhaust system with an inlet connected at several points on the limestone-receiving hoppers. The exhaust system will be sized to create a negative pressure at both the hopper inlet and the discharge at the conveyor belt. Dust will be removed from the exhaust air by a bag filter or a wet scrubber before the air is discharged into the atmosphere.

The reclaiming of limestone from the pile will be by underground hoppers. Because reclaiming occurs continuously, a depression will occur over the reclaim hoppers. The limestone delivery will be through an adjustable telescopic chute and will be so controlled that the quantity of limestone delivered will fill the depression in the storage pile. This process will minimize free fall and reduce particulate emissions. It is expected that bulldozer activity will be minimal, further reducing emissions.

From the reclaim hoppers the limestone will emerge above ground in a totally enclosed tubular conveyor that travels to the limestone day silos. A local exhaust system similar to the one used at the car dump facility will be provided at the reclaim hopper and any transfer house that may be required.

Each of the day silos will be provided with an exhaust system to create a negative pressure and prevent the escape of dust-laden air from the silos. Dust will be removed from the exhaust air by a bag filter and returned to the silo.

Based on the preliminary design given above, the only fugitive-emission point will be the limestone storage pile. All other fugitive-emission-generating processes will be totally enclosed and/or vented to dust-collection equipment.

Potential (uncontrolled) and controlled fugitive emissions from the limestone storage pile are covered in Section 2.1.4 of the technical guidance document. For the typical storage pile, the uncontrolled emission factor is 10.4 lb/acre-d on an area basis. This emission factor includes contributions from the following operations: loading onto the piles, equipment and vehicular movement in the storage area, wind erosion, and loadout from the piles. Potential emission, control efficiency, and controlled emission percentages for each operation are presented in Table 4-17. As indicated in the table, the control of emissions from all operations is 21 percent (i.e., 9 percent control of loadon emissions plus 12 percent control of loadout emissions). This translates to an overall reduction in fugitive emissions of 0.4 ton/yr--the difference between potential emissions of 1.9 ton/yr and controlled emissions of 1.5 ton/yr.

The emissions for the limestone car dump facility, limestone day silos, and fly-ash silos are presented in Table 4-18. These emissions are to be controlled by fabric filter dust collectors.

4.2.11 NOISE EMISSIONS

Ambient noise levels around the Big Bend Station are expected to increase during construction and operation of Unit 4. The major sources of construction noise will be the diesel-powered equipment operating onsite during the 3-year construction program. Since the sound levels over this period will continually vary with the different phases of construction and with day-to-day changes in construction equipment usage and sound propagation conditions, they are best characterized by the equivalent sound level (L_{eq}). The L_{eq} is the level of a constant sound which has the same sound energy as does a time-varying sound over the same time period. As such, the L_{eq} is representative of the long-term average sound levels expected at offsite locations.

Construction sound levels for Unit 4 were estimated by interpolating from the typical L_{eq} contours developed for the Empire State Electric Energy Research Corporation (Teplitzky and Wood 1978). These contours were based on noise measurements taken at 15 power plant sites during the 5 major phases of construction--grading and excavation, concrete pouring, steel erection, siding and machinery installation, and plant startup and site cleanup. The typical L_{eq} values were found to vary over a 5-decibel range during the primary construction phases, but they are significantly lower during the cleanup phase since few pieces of equipment are involved. Thus, to be conservative in estimating the potential impact of construction noise for Big Bend Unit 4, the highest L_{eq}s typical of the grading and excavation and steel-erection phases were used. The fluctuating character of construction noise was found to be similar during all construction phases, such that a constant relationship exists among the equivalent (L_{eq}), residual (L_{90}), median (L_{50}), intrusive (L_{10}), and peak (L_i) sound levels from construction, as indicated in the following expression:

$$L_{eq} \simeq L_i - 8 \simeq L_{10} - 2 \simeq L_{50} + 3 \simeq L_{90} + 7 \qquad (4\text{-}1)$$

The values of these descriptors of the construction noise were estimated for each measurement location used in the background noise survey (Section 5.1.3). The predicted equivalent and peak construction sound levels, as well as the measured ambient residual sound levels, are shown in Table 4-19 for each offsite measurement location. The peak sound levels can be considered to be maximum sound levels expected from construction of Unit 4 at any location.

The major continuous sources of operational noise from Big Bend Unit 4 will be the main transformers, boiler, forced-draft fans, primary air fans, induced-draft fans, flue gas desulfurization (FGD) system, and the turbine building. The sound generated by these sources will remain relatively constant for any operating load of the unit. The public address system and the coal-handling system will continue to be intermittent sources of operational noise. However, with the addition of Unit 4, the intermittent sound levels are not expected to change significantly from the intermittent sound levels currently generated by Units 1, 2, and 3. An additional source of intermittent noise will be the bulldozer and trucks used in the FGD gypsum storage/disposal area; however, bulldozer operation in this area will be limited to daytime hours.

Operational sound level predictions for Big Bend Unit 4 were made using manufacturer's data for the transformers, forced-draft fans, and induced-draft fans, and with typical sound level data from the Electric Power Plant Environmental Noise Guide (1978) for the other sources. The noise source data were developed as sound power levels for each piece of equipment. The sound level at each ambient measurement location was calculated assuming hemispheric propagation and atmospheric absorption under standard conditions (20°C, 70 percent RH). Also, the directivity effects of stack-radiated noise from the induced-draft fans and booster fans and the shielding of transformer noise by the turbine buildings were included in the calculation. Attenuation owing to meteorological and terrain effects was not included in the calculation. Sound power levels for the fans were reduced by approximately 15 decibels to account for noise control treatments. Sound levels predicted for the FGD gypsum disposal area bulldozer were the maximum levels expected during use of the Phase I portion of the disposal area.

The calculated continuous sound level contributions of Units 1, 2, and 3 were made using sound power levels computed from the onsite measurements made at Locations 1, 2, and 3 during the ambient survey. The sound levels from Units 1, 2, and 3 were calculated in the same manner as were the Unit 4 sound levels, assuming hemispheric propagation and atmospheric absorption under standard conditions. Again, these predicted sound levels did not include the attenuating effects of meteorological and terrain conditions.

The continuous sound levels from Units 1, 2, and 3 combined, from Unit 4, and from Units 1, 2, 3, and 4 combined, as well as the daytime and nighttime intermittent sound levels from Units 1, 2, 3, and 4 combined, are shown in Table 4-20 for each offsite ambient measurement location. The impacts of the construction noise and of the increase in operational noise are discussed in Sections 6.1.1.2 and 6.3.1.15, respectively.

Table 4-1. Water use at Big Bend Station[a] (Sheet 1 of 3)
(Thousands of gallons per day)

Line number[b]	Use	Average use	Maximum use	Nature[c]	Duration	Frequency
A	Activated-carbon bed influent	145.2	145.2	C	—	—
B	Activated-carbon bed effluent	144.9	144.9	C	—	—
C	Activated-carbon bed backwash	0.3	0.3	I	—	1 per week
D	Anion/cation bed effluent	115.0	115.0	C	—	—
E	Anion/cation bed backwash	29.9	29.9	I	—	1 every 30 hours
F	Mixed-resin bed effluent (boiler makeup)	114.2	114.2	C	—	—
G	Mixed-resin bed backwash	0.8	0.8	I	—	1 every 27 days
H	Neutralization/equalization effluent backwash	38.7	38.7	C	—	—
I	Condensate-polisher backwash makeup	8.0	8.0	I	—	1 every 4 days
J	Condensate-polisher backwash	8.0	8.0	I	—	1 every 4 days
K	Boiler blowdown	43.2	43.2	C	—	—
L	Boiler chemical cleaning waste	0.9	0.9	I	2 hours per stage	1 every 2 years
M	Vent losses	15.0	15.0	C	—	—
N	Soot-blowing losses	47.1	47.1	I	—	—
O	Service cooling-water makeup	210.0	210.0	C	—	—
P	Service cooling-water evaporation losses	138.0	138.0	C	—	—
Q	Service cooling-tower blowdown	72.0	72.0	C	—	—
R	High- and low-pressure fire protection system	Nil	Nil	I	—	—
S	Domestic service water	1.3	1.3	I	—	—
T	Sewage-treatment plant effluent	1.3	1.3	I	—	—
U	Hose connection	0.1	2.9	I	4 hours	1 every 4 weeks
V	Pump seals	10.8	10.8	C	—	—
W	Clinker/grinder seals	1.3	5.4	I	2 hours	3 per day
X	Coal equipment wash	2.1	2.1	I	16 hours	4 per year
Y	FGD system makeup	1,123.2	1,123.2	C	—	—

Note: See footnotes at end of table.

Table 4-1. Water use at Big Bend Station[a] (Sheet 2 of 3)
(Thousands of gallons per day)

Line number[b]	Use	Average use	Maximum use	Nature[c]	Duration	Frequency
Z	FGD slurry (85% water)	1,741.0	1,741.0	C	—	—
AA	FGD evaporation losses	989.3	989.3	C	—	—
BB	Hydroclone effluent to filter	316.8	316.8	C	—	—
CC	Vacuum-filter sludge (20% water)	74.9	74.9	C	—	—
DD	Vacuum-filter recycle	241.9	241.9	C	—	—
EE	Hydroclone recycle	1,424.4	1,424.4	C	—	—
FF	Recycle to FGD system	1,607.1	1,607.1	C	—	—
GG	FGD System Wash	66.6	133.3	I	—	—
HH	Service-water effluent	21.2	21.2	I	—	—
II	Wastewater-treatment system recycle	21.2	21.2	I	—	—
JJ	Air-preheater wash	9.4	9.4	I	8 hours	1 every 3 months
KK	Precipitator wash	5.3	5.3	I	80 hours	3 per year
LL	Economizer wash	0.3	0.3	I	4 hours	3 per year
MM	Sparging system	4.6	4.6	I	24 hours	3 per year
NN	External boiler wash	1.6	1.6	I	24 hours	2 per year
OO	Fly-ash pond blowdown	72.0	72.0	I	—	—
PP	Wastewater-treatment system percolation losses	30.0	30.0	C	—	—
QQ	Spray-irrigation system	169.5	183.4	I	—	—
RR	Construction Runoff	0	0	I	—	—
SS	Condenser cooling water	347,072.0	347,072.0	C	—	—
TT	FGD system blowdown	59.0	59.0	C	—	—
UU	Bottom-ash pond makeup	505.0	505.0	C	—	—
VV	Condenser cooling effluent	347,072.0	347,072.0	C	—	—
WW	Coal-storage runoff	—	—	I	—	—
XX	Bottom-ash recycle	1,825.0	1,825.0	C	—	—
YY	Fly-ash sluice-water makeup	72.0	72.0	I	—	—

Note: See footnotes at end of table.

Table 4-1. Water use at Big Bend Station[a] (Sheet 3 of 3)
(Thousands of gallons per day)

Line number[b]	Use	Average use	Maximum use	Nature[c]	Duration	Frequency
AAA	Bottom-ash sluice	2,300.0	2,300.0	I	—	—
BBB	Bottom-ash system evaporation losses	30.0	30.0	C	—	—
CCC	Fly-ash sluice	1,440.0	1,440.0	I	—	—
DDD	Fly-ash recycle	1,368.0	1,368.0	I	—	—
EEE	Bottom-ash pond percolation losses	360.0	360.0	C	—	—
FFF	Bottom-ash pond blowdown	115.0	115.0	C	—	—
GGG	Construction water uses	NA	NA	I	—	—
HHH	Domestic water uses	NA	NA	I	—	—
III	Condenser cooling-water makeup	15,408.0	15,408.0	C	—	—
JJJ	Condenser cooling-tower evaporation losses	5,184.0	5,184.0	C	—	—
KKK	Condenser cooling-tower blowdown	10,224.0	10,224.0	C	—	—

[a] From TECO (1981).
[b] See Figure 4-5.
[c] Key: C = continuous; I = intermittent.

Table 4-2. Expected influents and effluents of the demineralizer system for Big Bend Units 3 and 4

Parameter	Activated carbon filter	Combined anion-cation	Mixed bed
Quantity between regenerations			
Influent, gal	3,300,000	556,600	4,600,000
Effluent, gal	3,300,000	444,000	4,568,500
Design frequency of regenerations	Approximately once every 7 days	Approximately once every 45 hours	Approximately once every 20 days
Quantity of regeneration waste, gal	4,045	112,000	31,500

Note: All information in this table is for one demineralizer train, and it is identical for the other train.

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Waste source	pH	Conductivity (µmhos/cm)	Suspended solids	Dissolved solids	Volatile total solids	Non-combustible solids	TOC	Oil and grease	Phosphorous (total as P)	Nitrogen (nitrate as N)	Chromium (total)	Sodium	Potassium	Calcium	Magnesium
A Carbon filter backwash	7.64	610	16.7	611			4.0				32	24	47	160	60
B Boiler cleaning, Stage 1 (HCl drain)	1.3		9	10,345	9,005	4,465	210	36	02	915	005	11	15	60	23
C Boiler cleaning, Stage 2 (HCl rinse)	3.7		8	160	390	375	7	3	02	020	0005	11	18	44	9
D Boiler cleaning, Stage 3 (citric acid drain)	3.5		18	1.580	1,040	548	230	11	02	125	90	63	83	440	60
E Air preheater wash, first to composite sample	2.5	9.050	3,510	2.985	1,020	15.495	23	40	02	16	24	35	28	200	38
F Air preheater wash, composite of total washwater	2.4	4.200	3,933	4.294	620	6,030	12	40	101	25	42	45	68	90	40
G Preoperational boiler cleaning, Stage 1 (first acid drain)	1.9		20	6.045	9.775	6.290	260	8	95	43	02	12	15	50	25
H Preoperational boiler cleaning, Stage 2 (first acid rinse)	2.1		1	905	275	620	14	11	08	02	01	18	2	55	30
I Preoperational boiler cleaning, Stage 3 (citric acid drain)	2.5		10	1.313	109	620	440	11	03	015	058	225	20	982	388
J Total continuous wastewater stream[b]	7.14		2.331	831	196	496	023	12[illegible]	013	0.38	089	1378	403	920	338
K Continuous stream total boiler-cleaning wastes[b]	1.97		895	2.020	1.549	1.287	930	859	017	10	204	3096	2295	160	3016
L Continuous stream total composite APW water[b]	2.69		1,902	3.865	530	4.995	108	346	011	205	194	2341	287	160	345
M Continuous stream total preoperational boiler-cleaning wastes[b]	2.31	3.857	17.06	3.940	2.243	1.722	167	25	198	90	003	1356	56	129	136
N Demineralizer wastewater			146	4.869	391	4.341	44.6	1	0.1	011	039	478	522	109	303
O Continuous stream demineralizer wastes[b]			64.9	1.966	236	1.801	19.2	1.16	0.12	029					

Abbreviations:
TOC = total organic carbon.
JTU = Jackson turbidity units.
APW = air preheater wash.

[a] All units in ppm unless otherwise noted.
[b] Continuous stream includes floor drainage and cooling-tower blowdown from all units, including package-sewage-treatment plant.

Table 4-3. Chemical composition of freshwater wastes[a]

mium al)	Sodium	Potassium	Calcium	Magnesium	Chloride	Sulfate	Bromide	Fluoride	Iron (total)	Iron (dissolved)	Vanadium	Copper	Zinc	Nickel	Manganese	Acidity to pH (4.4 as $CaCO_3$)	Acidity to pH (8.2 as $CaCO_3$)	Turbidity (JTU)
32	26	47	160	60	61,300	84		10	3,200		14	10	8	18	199	71,600	76,000	
005	11	15	60	23	1,000	40	040	15	86		0022	005	01	01	040	215	420	
0005	11	18	44	9	225	30	18	8	10		01	1005	1008	005	01	100	818	
90	63	83	440	60	28	2,740	13	15	2,500	2,250	25	48	20	830	110 80	5,460 950	8,450 2,550	1,000 1,000
34	35	28	200	38	25	625	05	55	1,040	850	25	18	18	220				
42	43	68	90	40	151	30	06	960	6,600		25	28	24	28	50	18,000	71,500	
02	12	15	50	25		30	19	50	252		01	005	05	015	18	1,480	1,780	
01	18	2	55	30	385	40	21	10	186		007	005	02	01	1	770	1,050	
018	225	20	982	388	914	879	025	61	57	108	01	005	139	005	009			
009	1378	403	920	338	12,735	865	369	646	663		035	024	220	041	121	14,938	35,940	
04	3096	2295	160	3016	2,624	482	045	465	838	685	187	122	172	170	404	731	2,055	804
04	2341	287	160	345	175	847	216	203	1,428		058	061	555	064	1067	14,181	18,077	
005	1356	56	129	136	187	2,041	010	029	089	033	0003	1005	1005	005	1005			44
039	478	522	109	303	848	1,021	04	05	079	018	007	1008	094	005	1005			

Table 4-4. Wastewater-recycle design flows

Operation	Flow (gpm)	Duration (hr/d)	Total daily flow (gal)
1. Air preheater wash	2150	5	645,000
2. Precipitator wash	400	24	576,000
3. Economizer wash	100	4	24,000
4. Sparging system	160	24	230,400
5. Boiler external wash	400	24	576,000
6. Slag tank wash	100	4	24,000
7. Coal field	200	16	192,000
8. Slag tank aspirators	100	24	144,000

Table 4-5. Flow and velocity characteristics of the condenser-cooling-water systems for Big Bend Units 1-4

Parameter	Unit 1	Unit 2	Unit 3	Unit 4
Intake channel				
Flow rate, cfs	537	537	537	537
Cumulative flow, cfs	2,148	1,611	1,074	537
Velocity, fps	0.56	0.42	0.28	0.14
Discharge channel				
Unit flow, cfs	537	537	537	537
Cumulative flow, cfs	2,148	1,611	1,074	537
Velocity, fps	0.25	0.18	0.12	0.06

Table 4-6. Wastewater recycle design flows associated with Big Bend Unit 4[a,b]

Operation	Average flow (gpd)	Maximum flow (gpd)	Duration (hr)	Frequency
FGD system wash	66,600	133,300	--	--
Air preheater wash	9,400	9,400	8	1 every 3 months
Precipitator wash	5,300	5,300	80	3 per year
Economizer wash	300	300	4	3 per year
Sparging system	4,600	4,600	24	3 per year
Boiler external wash	1,600	1,600	24	2 per year

[a] Adapted from Tampa Electric Company (1981).
[b] All flows intermittent in nature.

Table 4-7. Design Coal Analysis[a]

Parameter	F-1A		F-2A		F-2B	
	As received	Dry basis	As received	Dry basis	As received	Dry basis
Heating value (Btu/lb)	10,495	12,275	11,300	12,626	11,050	12,628
Ultimate analysis (percent by weight)						
Moisture	14.50	--	10.50	--	12.50	--
Carbon	57.00	66.67	62.50	69.80	61.50	70.30
Hydrogen	4.10	4.80	4.30	4.80	4.10	4.68
Nitrogen	1.08	1.26	1.30	1.45	1.20	1.37
Sulfur	2.92	3.42	3.50	3.90	3.50	4.00
Ash	13.50	15.79	10.50	11.73	10.00	11.40
Oxygen	7.05	8.25	7.20	8.10	7.10	8.10
Chlorine	0.08	0.09	0.20	0.22	0.10	0.11
Proximate analysis (percent by weight)						
Moisture	14.52	--	10.50	--	12.50	--
Ash	13.50	15.79	10.50	11.73	10.00	11.40
Volatile matter	30.21	35.33	34.50	38.54	34.50	39.40
Fixed carbon	41.75	48.83	44.50	49.72	43.00	49.10
Sulfur	2.92	3.42	3.50	3.91	3.50	4.00
Ash analysis (percent by weight)						
Phosphorus pentoxide	0.34	--	0.13	--	0.16	--
Silicon dioxide	46.74	--	45.60	--	44.70	--
Ferric oxide	17.71	--	20.70	--	19.00	--
Aluminum oxide	19.25	--	19.20	--	20.70	--
Titanium	1.01	--	0.90	--	1.10	--
Calcium oxide	6.49	--	4.90	--	4.50	--
Magnesium oxide	0.70	--	0.94	--	1.00	--
Sulfur trioxide	4.31	--	4.70	--	5.50	--
Potassium monoxide	1.54	--	2.20	--	2.50	--
Sodium oxide	1.37	--	0.50	--	0.50	--

Type of Coal

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[a] Adapted from Environmental Research and Technology, Inc. (1979).

Table 4-8. Solid wastes produced by Big Bend Station Unit 4

Waste material	Quantity (tons/yr)[a]
Bottom ash[b]	25,680
Pyrites[c]	19,000
Fly ash[d]	102,700
FGD by-product (gypsum)	210,000

[a] Based on use of F-1A coal (ash content, 13.5%) and on a 28-year average capacity factor of 52.75%.

[b] Bottom ash assumed to be 20% of ash content.

[c] Pyrites assumed to be 2% of coal.

[d] Fly ash assumed to be 80% of ash content.

Table 4-9. Production rate of fly ash and bottom ash from Big Bend Station Unit 4[a]

Parameter	Rate (lb/hr)	Annual rate (tons/yr)[b]
Fuel rate	413,000	950,000
Total ash	55,755	128,380
Bottom ash	11,151	25,680
Fly ash at ESP inlet	44,604	102,700
Fly ash collected in ESP	44,474	102,400
Fly ash at ESP outlet[b]	130	300

[a] Based on use of F-1A coal (high heat value, 10,495 Btu/lb; ash content, 13.5%) and on a capacity factor of 52.75%.

[b] Based on outlet particulate loading equivalent to 0.03 lb/10^6 Btu.

Table 4-10. Full-load operating and emission parameters for Big Bend Station

Parameter	Unit 1	Unit 2	Unit 3
Fuel data:			
Type	Coal	Coal	Coal
Sulfur content (%)	3.3	3.3	3.3
Ash content (%)	11.0	11.0	11.0
HHV (Btu/lb)	11,000	11,000	11,000
Generation (MW)	362	338	362
Heat input rate (10^6 Btu/hr)	4,037	3,996	4,115
Fuel rate (10^3 lb/hr)	367	363	374
Flue gas rate (10^3 lb/hr)	4,049	4,066	4,155
Exit temperature (°F)	301	301	292
Stack dimensions:			
ID (ft)	24[a]		24
Height (ft)	490[b]		490
Emissions (lb/hr):[b]			
SO_2	26,240	25,971	26,749
PM	403	400	412
NO_x	2,826	2,797	2,881
CO	218	216	223
HC	1.8	1.8	1.9

Abbreviations:
HHV = high heat value.
ID = internal diameter.
PM = particulate matter.

[a] Stack common to Units 1 and 2.

[b] Units 1 through 3 are limited to a sulfur content of 6.5 lb/10^6 Btu (as SO_2) on a 2-hour average, an emission of 31.5 tons/hr on a 3-hour average, and 25 tph on a 24-hour average, per the Florida air pollution regulations.

Table 4-11. New source performance standards for electric utility steam-generating units

Pollutant	Emission limitation	Reduction requirement
SO_2	1.2 lb/10^6 Btu (520 ng/J)	90% (30-day rolling average)
	0.6 lb/10^6 Btu (260 ng/J)	70% (30-day rolling average)
PM	0.03 lb/10^6 Btu (13 ng/J)	99%[b]
	Opacity limited to 20% (6-min average); 27% allowed 6 min/hr[a]	
NO_2	0.6 lb/10^6 Btu (260 ng/J)	65%[b]

[a] A source-specific opacity standard may be established if opacity is greater than 20% when complying with the PM limitation.

[b] Satisfied automatically if emission limitation is met.

Table 4-12. Florida emission limiting standard for new solid fossil fuel steam generators (≥250 x 10^6 Btu/hr)

Pollutant	Emission limitation	Percentage reduction requirement
SO_2	1.2 lb/10^6 Btu	Maximum 2-hr average
PM	0.1 lb/10^6 Btu	Maximum 2-hr average
NO_2	0.7 lb/10^6 Btu	Maximum 2-hr average
Visible emission	Density equal to or greater than Number 1 of the Ringelmann Chart (20% opacity) except that shade as dark as Number 2 of the Ringelmann Chart (40% opacity) shall be permissible for no more than 2 min/hr	

Table 4-13. Pollutant emissions summary for Big Bend Station Unit 4

Pollutant	Pollutant emission			Applicable NSPS/SIP requirement
	lb/hr	lb/10^6 Btu	Percent reduction	
PM	129.9	0.03	99.7	0.03 lb/10^6 Btu
NO_x	2,598.0	0.60	65.0	0.60 lb/10^6 Btu
SO_2[a]	2,592.0-5,184.0	0.60-1.20	90.0	90% reduction
CO	245.7	0.057	NA	NA
HC	2.1	0.0005	NA	NA

[a] SO_2 emission represents range of sulfur content of raw coals of 3.0 and 6.0 lb/10^6 Btu.

Table 4-14. Full-load boiler performance data for Big Bend Station Unit 4

Parameter	Value
Steam generation (10^6 Btu/hr)	3,300
Heat input rate (10^6 Btu/hr)	4,330
Fuel rate (10^3 lb/hr)[a]	413
Excess air (%)	25
Flue gas rate (10^3 lb/hr)[b]	4,829
Flue gas temperature (°F)	267

[a] Based on hypothetical fuel with the following analysis:

Type	Coal
Sulfur content (%)	3.02
Ash content (%)	10.7
Moisture content (%)	15.0
High heat value (Btu/lb)	10.495

[b] Includes air preheater leakage.

Table 4-15. Summary of fugitive dust emissions from coal-handling operations at Big Bend Station Unit 4

Process	Emission source	Source number[b]	Basic emission factor[a] (lb/ton)	Annual potential emissions (tons/yr)	Control efficiency (%)	Controlled emissions (tons/yr)
Barge unloading	Bucket elevator	1	0.4	190.2	90.0	19.0
Transfer/conveying to storage piles (existing)	Transfer Tower A					
	A belt to B belt	2	0.2	95.1	95.0	4.8
	B belt to surge hopper	3	0.2	95.1	95.0	4.8
	Surge hopper to C belt	4	0.2	95.1	95.0	4.8
	C belt to D belt	5	0.2	95.1	95.0	4.8
	Transfer Tower 1	6	0.2	95.1	95.0	4.8
	Transfer Tower 2	7	0.2	95.1	95.0	4.8
	Stacker/reclaimer	8	0.2	95.1	95.0	4.8
Storage piles (existing)	Loadon, loadout, wind erosion, vehicular traffic	9	0.074	35.2	34.6	23.0
Transfer/conveying to surge pile	Surge hopper to H belt	10	0.2	95.1	95.0	4.8
	H belt to F belt	11	0.2	95.1	95.0	4.8
	Transfer Tower 3	12	0.2	95.1	95.0	4.8
Surge pile (existing)	Loadon, loadout, wind erosion, vehicular traffic	13	0.074	35.2	12.0	31.0

[a] Represents potential or uncontrolled emissions.
[b] See Figure 4-17.

Table 4-16. Type and control efficiency for coal storage piles

Operation	Percent of total emissions	Control	Control efficiency (%)	Overall control (%)
Loading onto piles	12	Adjustable rate	75	9.0
Vehicular movement	40	Watering/traveling boom	50	20.0
Wind erosion	33	--	0	0.0
Loadout	15	Stacker/reclaimer	37	5.6
Total				34.6

Table 4-17. Potential and controlled fugitive emissions from limestone storage pile

Operation	Percent of total emissions	Control efficiency (%)	Resulting control (%)
Loading onto piles	12	75	9
Vehicular movement	40	--	--
Wind erosion	33	--	--
Loadout	15	80	12
Overall control			21

Table 4-18. Emission rates and stack parameters for the Big Bend Station Unit 4 limestone- and fly-ash-handling systems

Source	Emission rate (lb/hr)	Stack height (ft)	Stack temperature (°F)	Velocity (ft/s)	Diameter (ft)
Car dump facility	0.63	42.[illegible]	10° above ambient	168.0	0.95
Day silos	0.05	75.1	10° above ambient	17.4	0.82
Fly-ash silos	0.19	118.1	20° above ambient	3.9	2.49

Table 4-19. Construction sound levels of Big Bend Station Unit 4[a]

Ambient measurement location	Daytime ambient residual sound level[b]	Equivalent construction sound level (L_{eq})	Peak construction sound level (L_1)
Location 4--7,500 ft NE at Adamsville	46	38	46
Location 5--3,800 ft ESE at Big Bend Road	53	48	56
Location 6--4,000 ft S at Newman Branch Road	43	47	55
Location 7--8,000 ft SSW at Apollo Beach Road	43	37	45
Location 8--8,000 ft SW at Apollo Beach Motel	45	37	45

[a] dBA referenced to 0.0002 microbar.

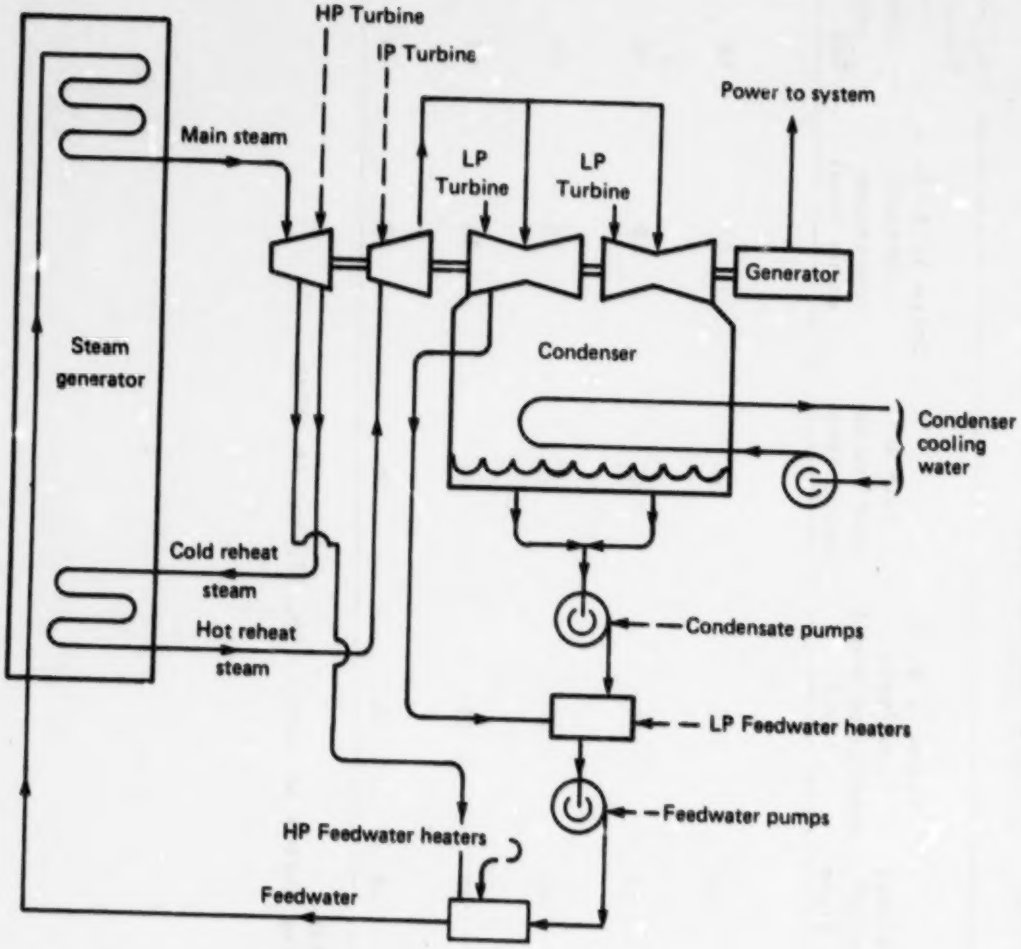
[b] Average of daytime values obtained during survey of January 16, 17, and 18, 1978.

Table 4-20. Predicted maximum operational sound levels[a]

Ambient measurement locations	Ambient residual sound levels[b]		Units 1, 2, 3 (combined) continuous sound level	Unit 4 continuous sound level	Units 1, 2, 3, 4 (combined) continuous sound level	Units 1, 2, 3, 4 (combined) intermittent sound level	
	Day	Night				Day	Night
Location 4 7,500 ft NE at Adamsville	46	43	36	39	41	46	46
Location 5 3,800 ft ESE at Big Bend Road	53	52	45	46	49	56	55
Location 6 4,000 ft S at Newman Branch Road	43	44	44	45	48	60	54
Location 7 8,000 ft SSW at Apollo Beach Road	43	37	35	36	39	47	45
Location 8 8,000 ft SW at Apollo Beach Motel	45	42	35	36	39	45	45

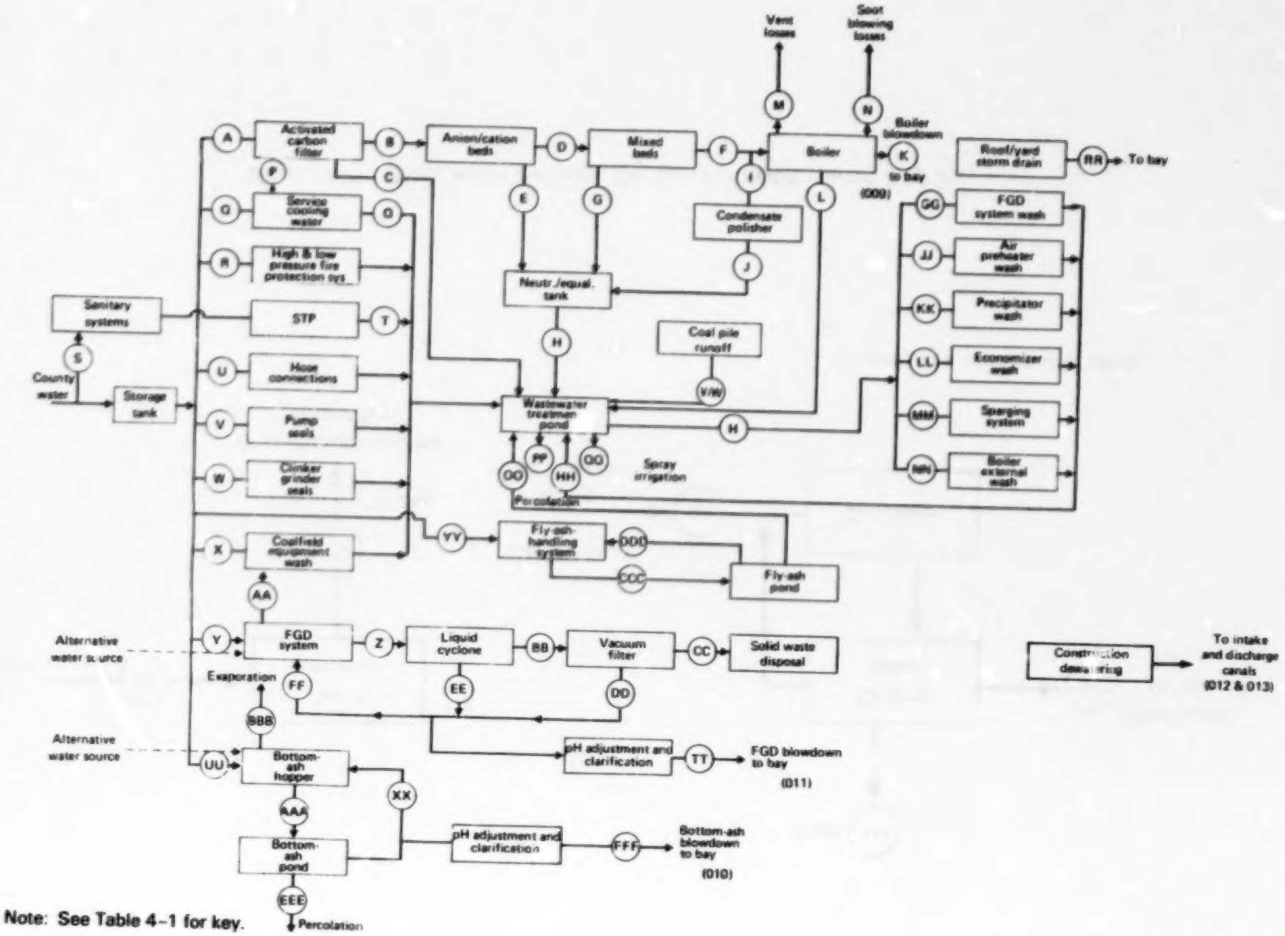
[a] dBA referenced to 0.0002 microbar.

[b] Average of values obtained during survey of January 16, 17, and 18, 1978.


HP Turbine
IP Turbine
Power to system
Main steam
LP Turbine
LP Turbine
Generator
Steam generator
Condenser
Condenser cooling water
Cold reheat steam
Hot reheat steam
Condensate pumps
LP Feedwater heaters
Feedwater pumps
HP Feedwater heaters
Feedwater

HP	High pressure
IP	Intermediate pressure
LP	Low pressure

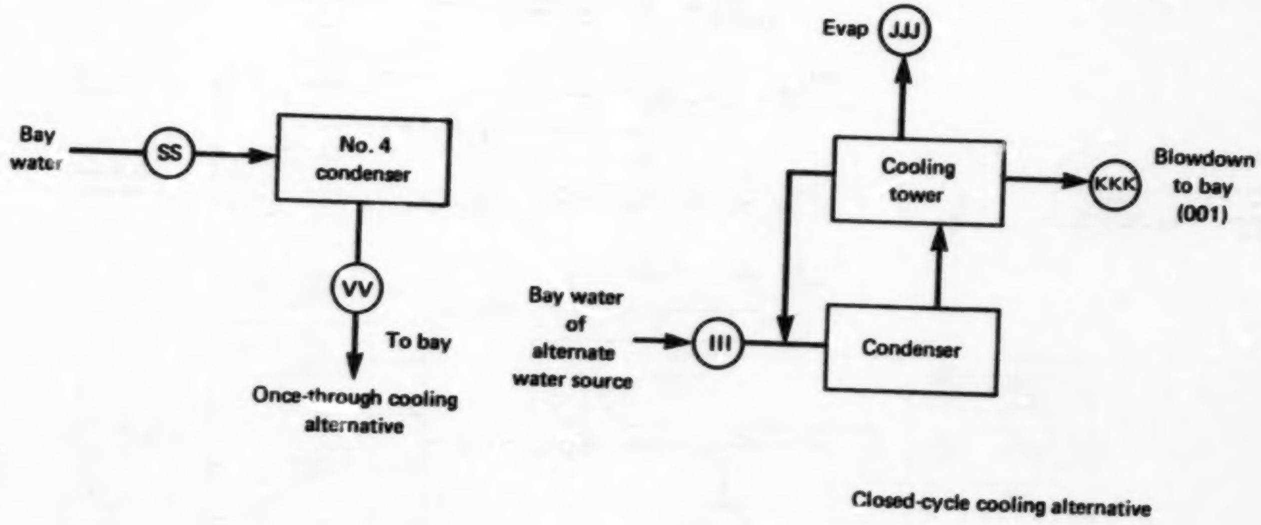
Figure 4-4. Steam-generated electric power system, Big Bend Station.


Vent losses
Soot blowing losses
M
N
Boiler blowdown
K
to bay
(009)
A
Activated carbon filter
B
Anion/cation beds
D
Mixed beds
F
Boiler
Roof/yard storm drain
RR
To bay
P
C
E
G
I
L
Service cooling water
O
Condensate polisher
GG
FGD system wash
High & low pressure fire protection sys.
R
J
JJ
Air preheater wash
Neutr./equal. tank
KK
Precipitator wash
Sanitary systems
STP
T
H
Coal pile runoff
S
LL
Economizer wash
County water
U
Hose connections
Storage tank
VW
Wastewater treatment pond
H
MM
Sparging system
V
Pump seals
PP
QQ
W
Clinker grinder seals
OO
HH
Spray irrigation
NN
Boiler external wash
Percolation
YY
Fly-ash handling system
DDD
X
Coalfield equipment wash
CCC
Fly-ash pond
AA
Alternative water source
Y
FGD system
Z
Liquid cyclone
BB
Vacuum filter
CC
Solid waste disposal
Construction dewatering
To intake and discharge canals (012 & 013)
Evaporation
FF
EE
DD
BBB
Alternative water source
pH adjustment and clarification
TT
FGD blowdown to bay
(011)
UU
Bottom-ash hopper
XX
AAA
Bottom-ash pond
pH adjustment and clarification
FFF
Bottom-ash blowdown to bay
(010)
EEE
Percolation

Note: See Table 4-1 for key.

Source: TECO (1981).

Figure 4-5. Plant water balance for the Big Bend Station (Sheet 1 of 2).


Bay water
SS
No. 4 condenser
VV
To bay
Bay water of alternate water source
III
Condenser
Cooling tower
Evap
JJJ
KKK
Blowdown to bay (001)

Once-through cooling alternative

Closed-cycle cooling alternative

Figure 4–5. Plant water balance, Big Bend Station (Sheet 2 of 2).

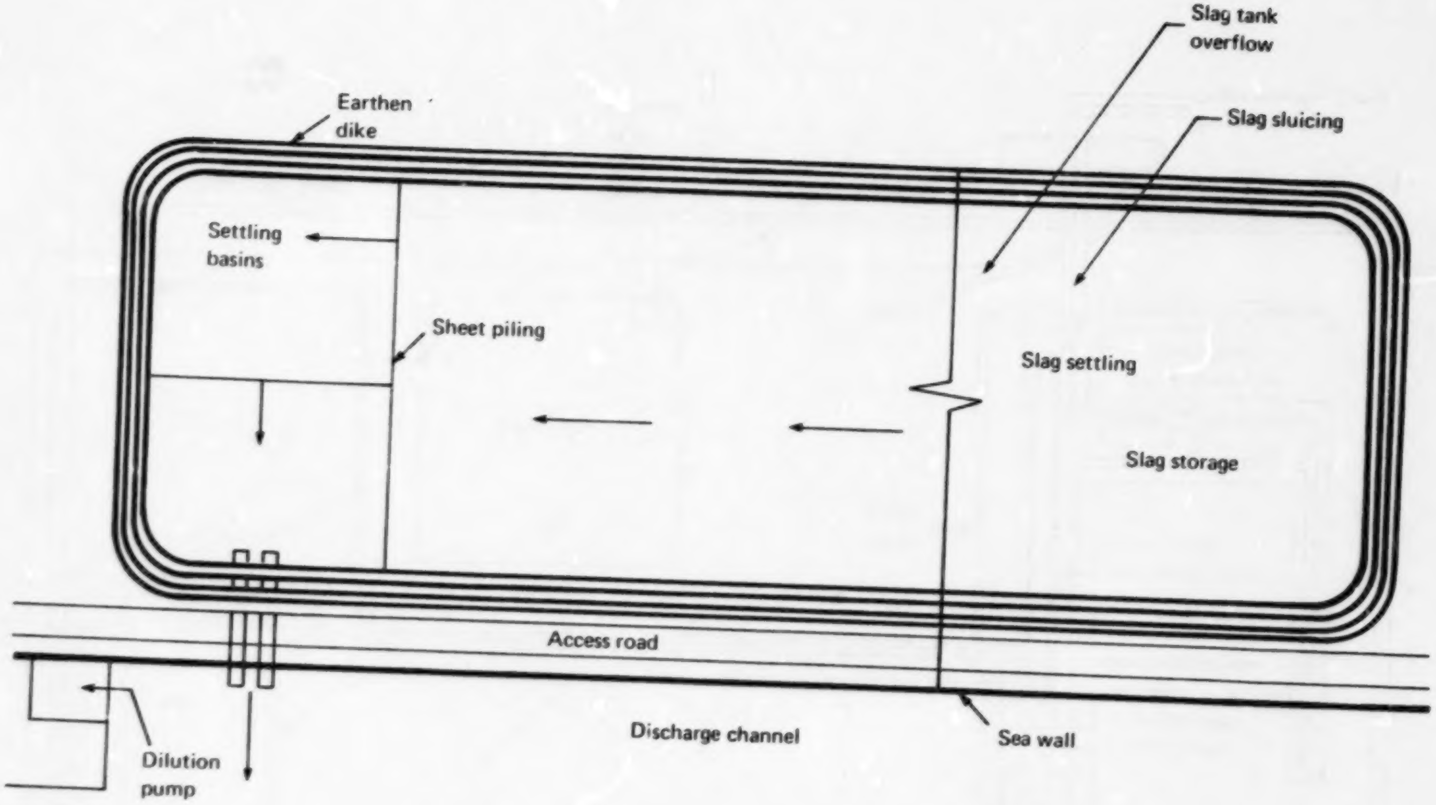

Slag tank overflow
Earthen dike
Slag sluicing
Settling basins
Sheet piling
Slag settling
Slag storage
Access road
Dilution pump
Discharge channel
Sea wall

Figure 4-6. Detail of slag pond at Big Bend Station.

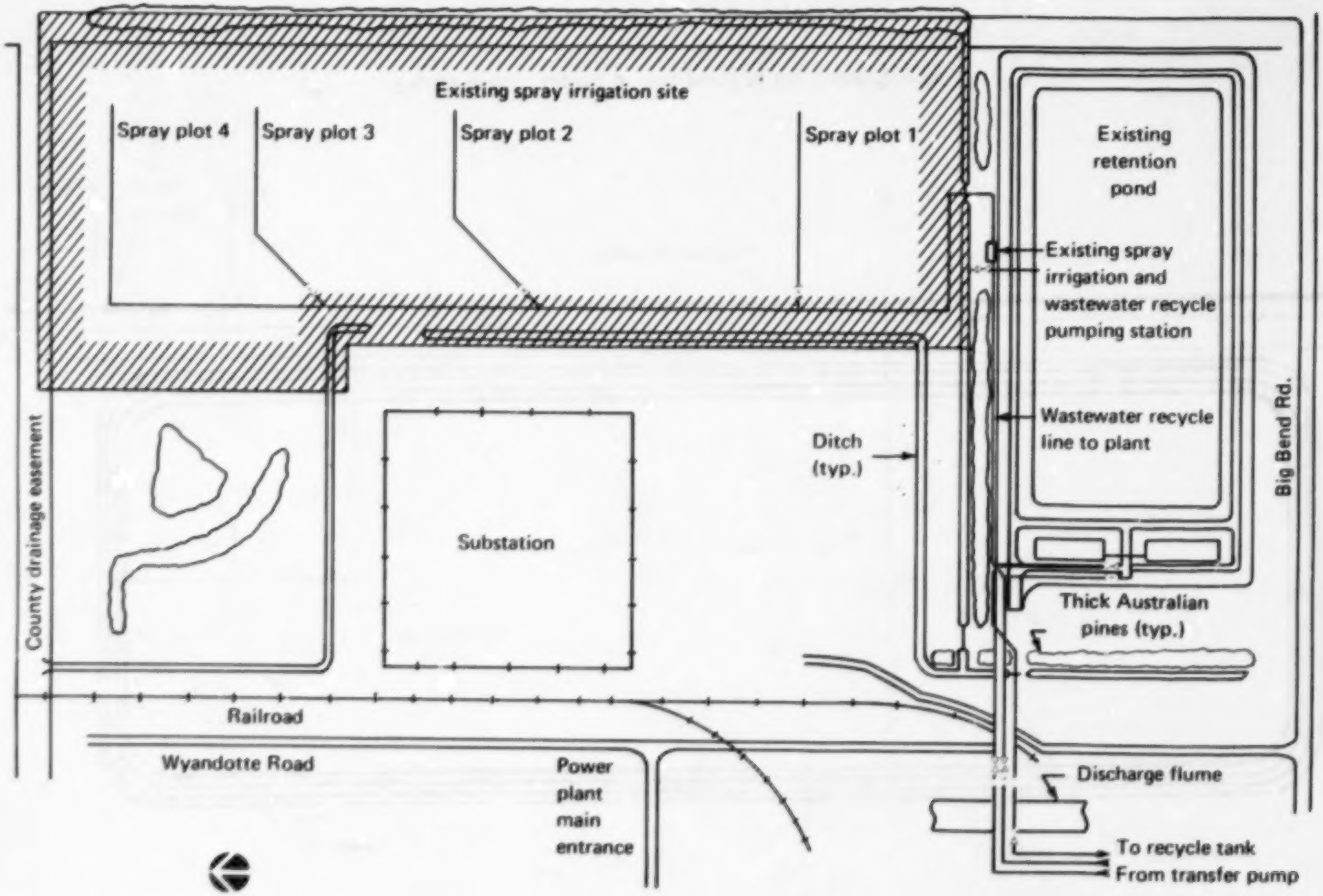

Existing spray irrigation site
Spray plot 4
Spray plot 3
Spray plot 2
Spray plot 1
Existing retention pond
Existing spray irrigation and wastewater recycle pumping station
Wastewater recycle line to plant
Big Bend Rd.
Ditch (typ.)
Substation
County drainage easement
Thick Australian pines (typ.)
Railroad
Wyandotte Road
Power plant main entrance
Discharge flume
To recycle tank
From transfer pump

Figure 4-7. Wastewater-treatment-pond irrigation systems at Big Bend Station.

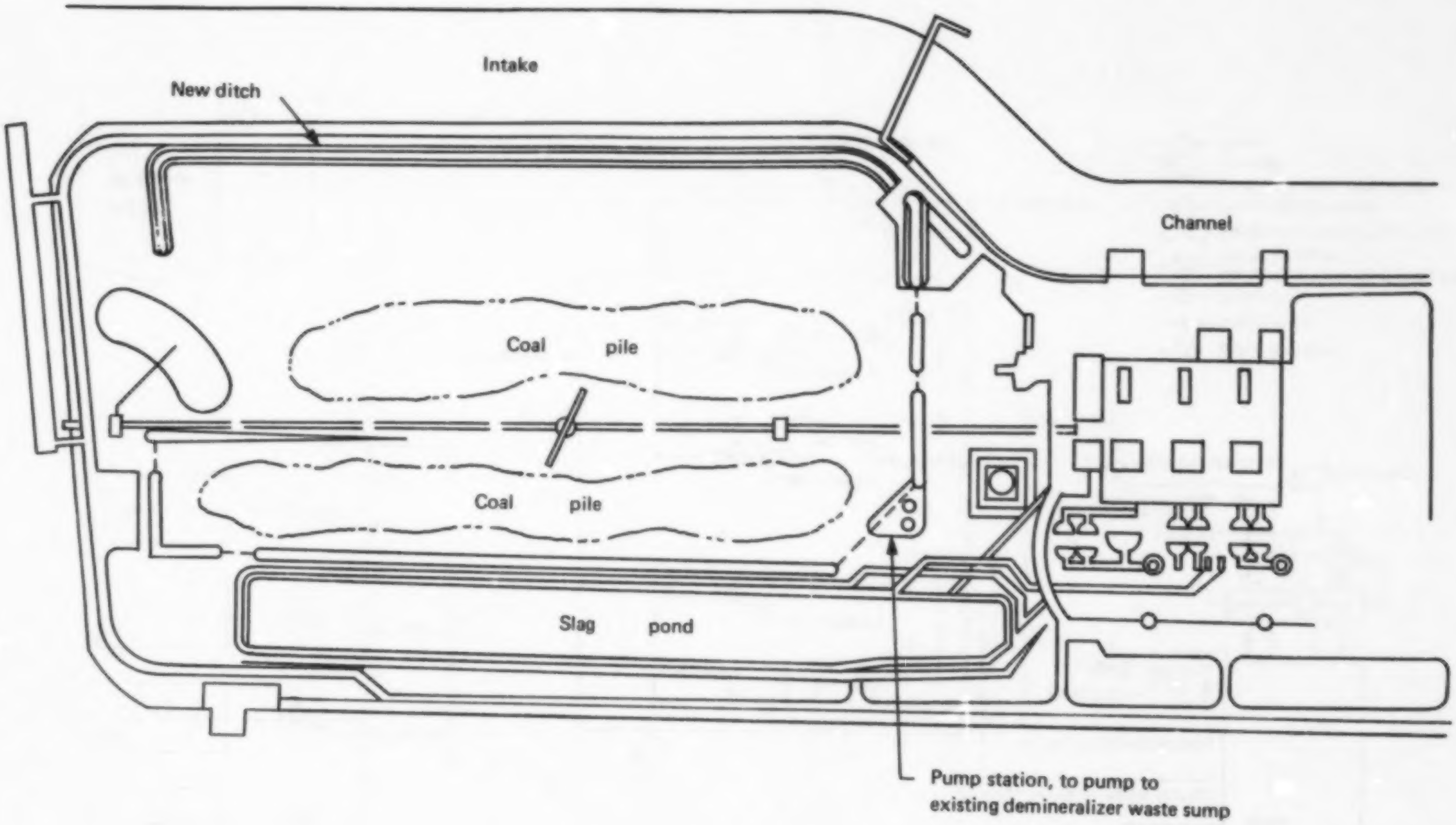

Intake
New ditch
Channel
Coal pile
Coal pile
Slag pond
Pump station, to pump to existing demineralizer waste sump

Figure 4-8. Coal-pile-runoff collection and treatment system, Big Bend Station.

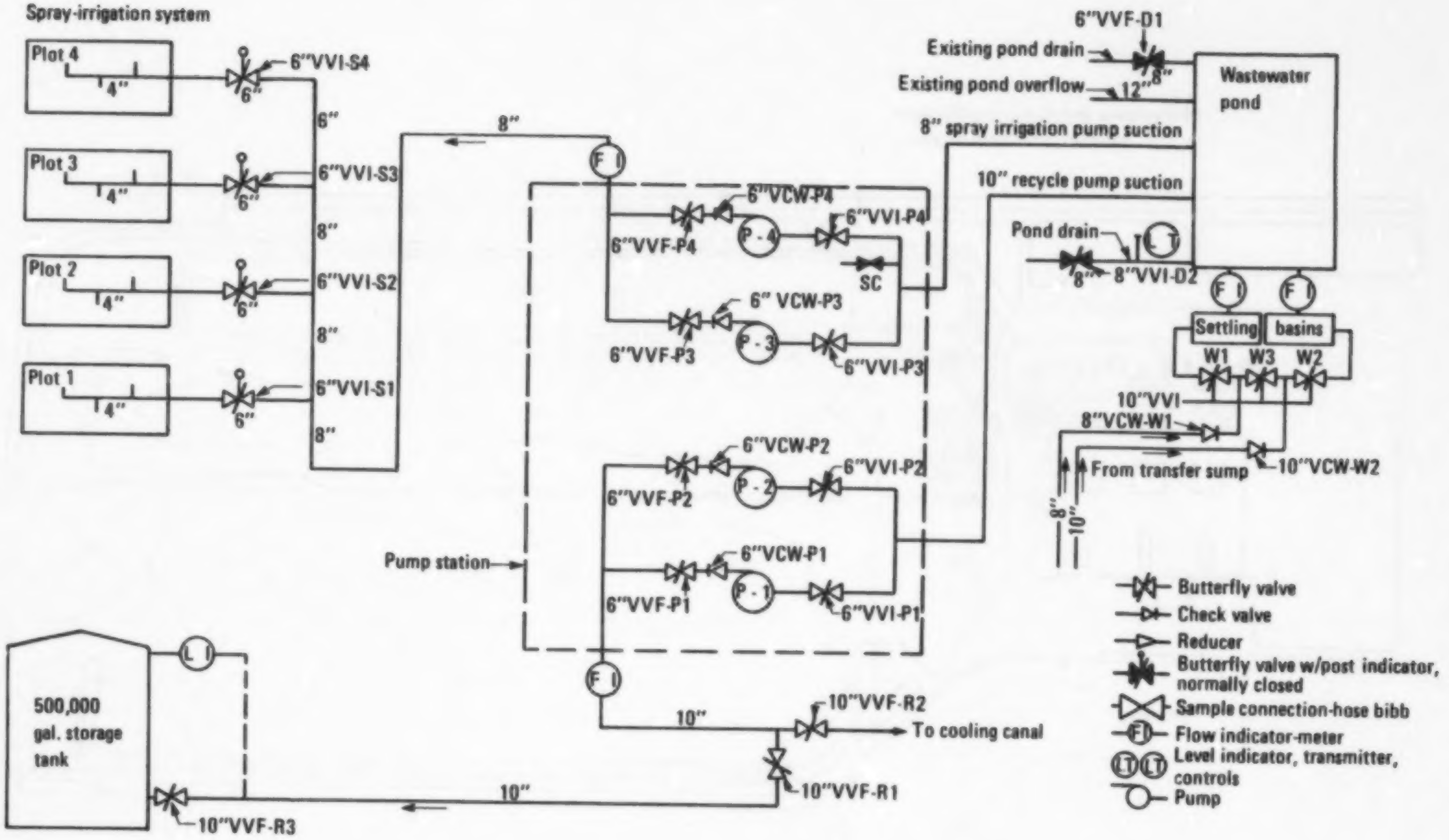

Spray-irrigation system
Plot 4
Plot 3
Plot 2
Plot 1
4"
6"
6"VVI-S4
6"VVI-S3
6"VVI-S2
6"VVI-S1
8"
Pump station
6"VCW-P4
6"VVI-P4
6"VVF-P4
P-4
SC
6" VCW-P3
6"VVF-P3
P-3
6"VVI-P3
6"VCW-P2
6"VVI-P2
6"VVF-P2
P-2
6"VCW-P1
6"VVF-P1
P-1
6"VVI-P1
FI
500,000 gal. storage tank
LI
10"
10"VVF-R3
10"VVF-R2
To cooling canal
10"VVF-R1
6"VVF-D1
Existing pond drain
Existing pond overflow
12"
Wastewater pond
8" spray irrigation pump suction
10" recycle pump suction
Pond drain
LT
8"VVI-D2
Settling basins
W1
W3
W2
10"VVI
8"VCW-W1
From transfer sump
10"VCW-W2
Butterfly valve
Check valve
Reducer
Butterfly valve w/post indicator, normally closed
Sample connection-hose bibb
Flow indicator-meter
Level indicator, transmitter, controls
Pump

Figure 4-9. Flow diagram of the wastewater disposal/recycle system at Big Bend Station.

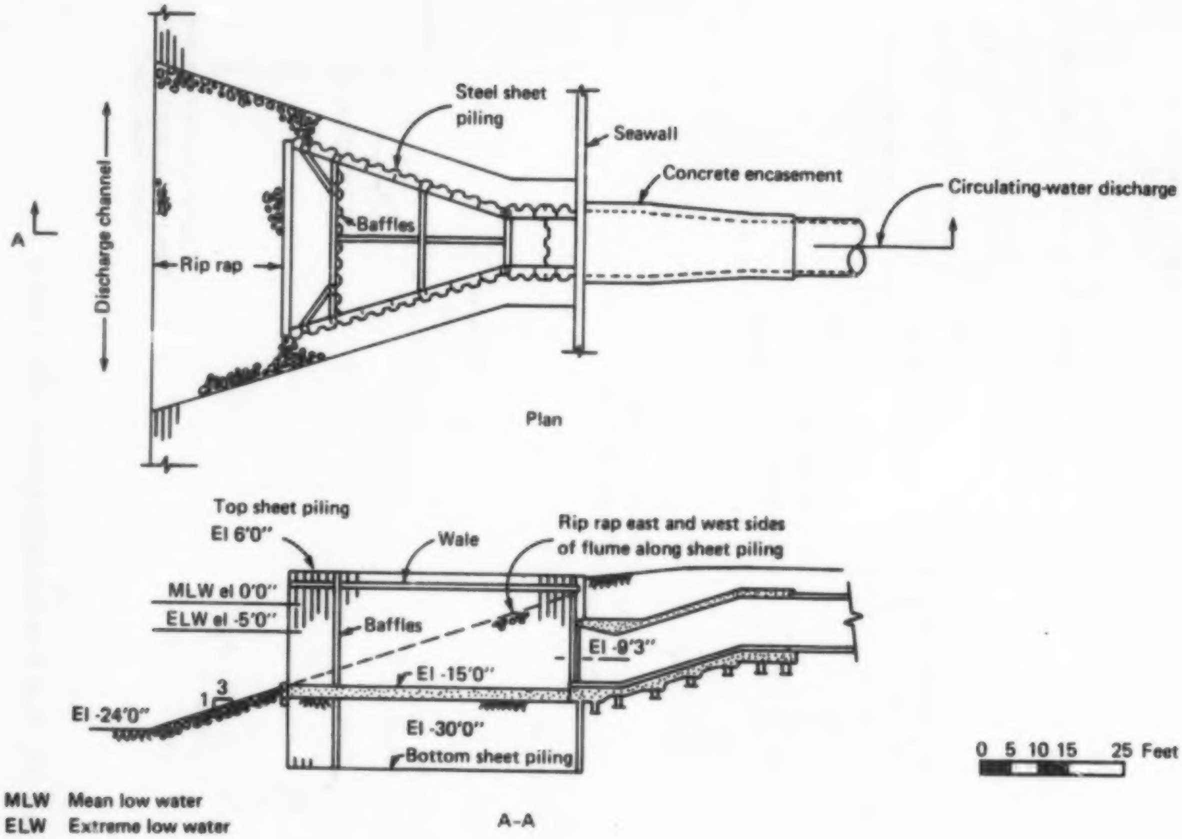
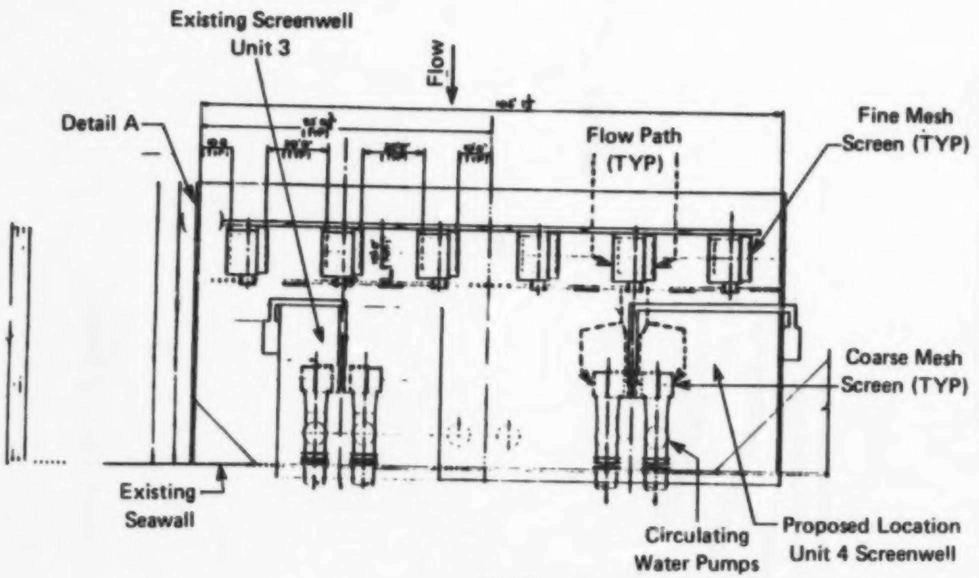
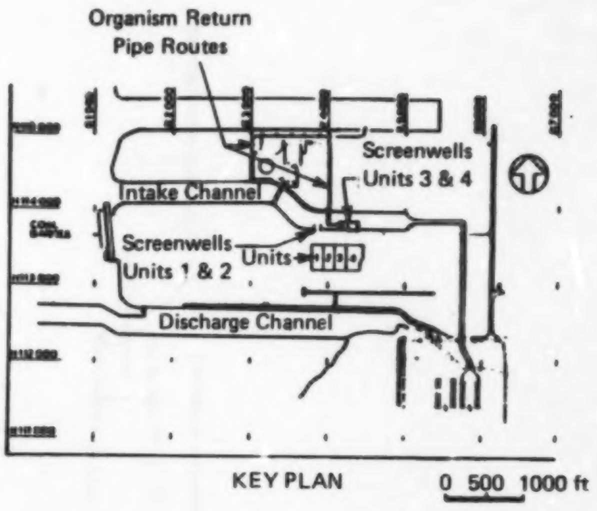

Steel sheet piling
Seawall
Concrete encasement
Circulating-water discharge
Discharge channel
A
Baffles
Rip rap
Plan
Top sheet piling
El 6'0"
Wale
Rip rap east and west sides of flume along sheet piling
MLW el 0'0"
ELW el -5'0"
Baffles
El -9'3"
El -15'0"
1
3
El -24'0"
El -30'0"
Bottom sheet piling
0 5 10 15 25 Feet
MLW Mean low water
ELW Extreme low water
A-A

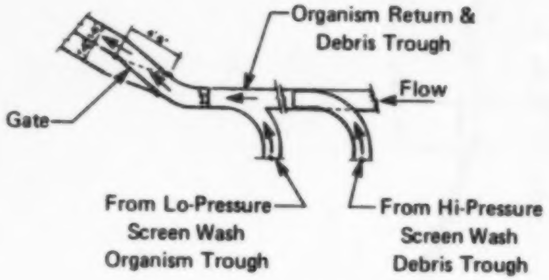
Figure 4-10. Discharge structure at Big Bend Station.


Existing Screenwell
Unit 3
Flow
Detail A
Flow Path
(TYP)
Fine Mesh
Screen (TYP)
Coarse Mesh
Screen (TYP)
Existing
Seawall
Circulating
Water Pumps
Proposed Location
Unit 4 Screenwell

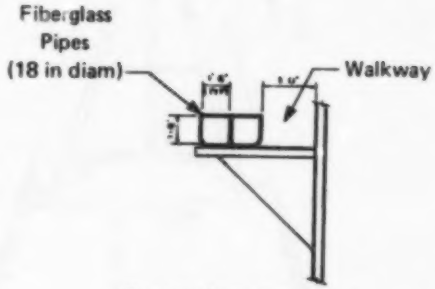
PLAN
SCREEN ARRANGEMENT


Organism Return
Pipe Routes
Screenwells
Units 3 & 4
Intake Channel
Screenwells
Units 1 & 2
Units
Discharge Channel
0 500 1000 ft

KEY PLAN


Organism Return &
Debris Trough
Flow
Gate
From Lo-Pressure
Screen Wash
Organism Trough
From Hi-Pressure
Screen Wash
Debris Trough

Detail A


Fiberglass
Pipes
(18 in diam)
Walkway

Typical Organism Return
Pipe (with Support Structure
Where Applicable)

Source: TECO (1980b).

Figure 4-11. Dual flow fine-mesh screens, Units 3 and 4.

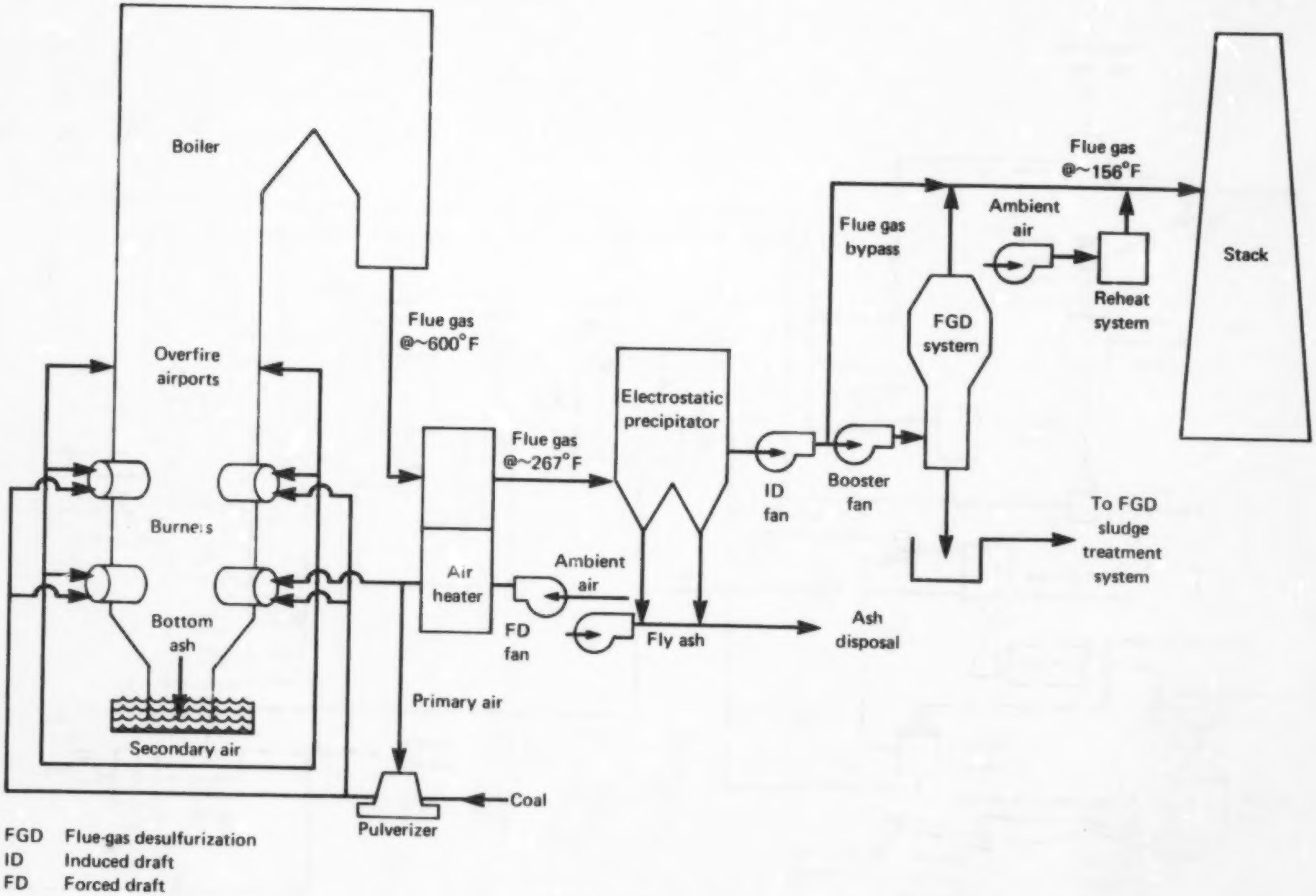
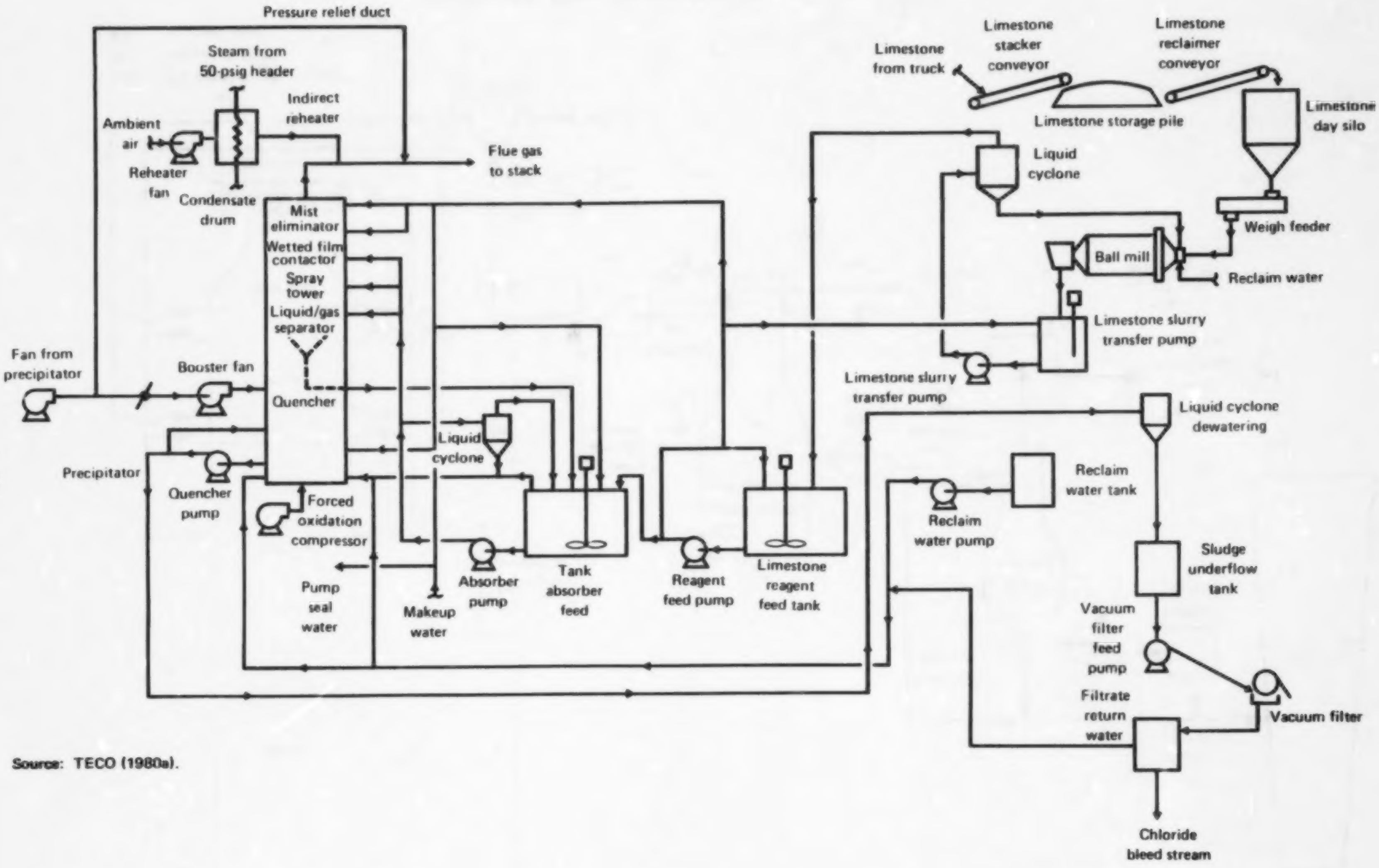
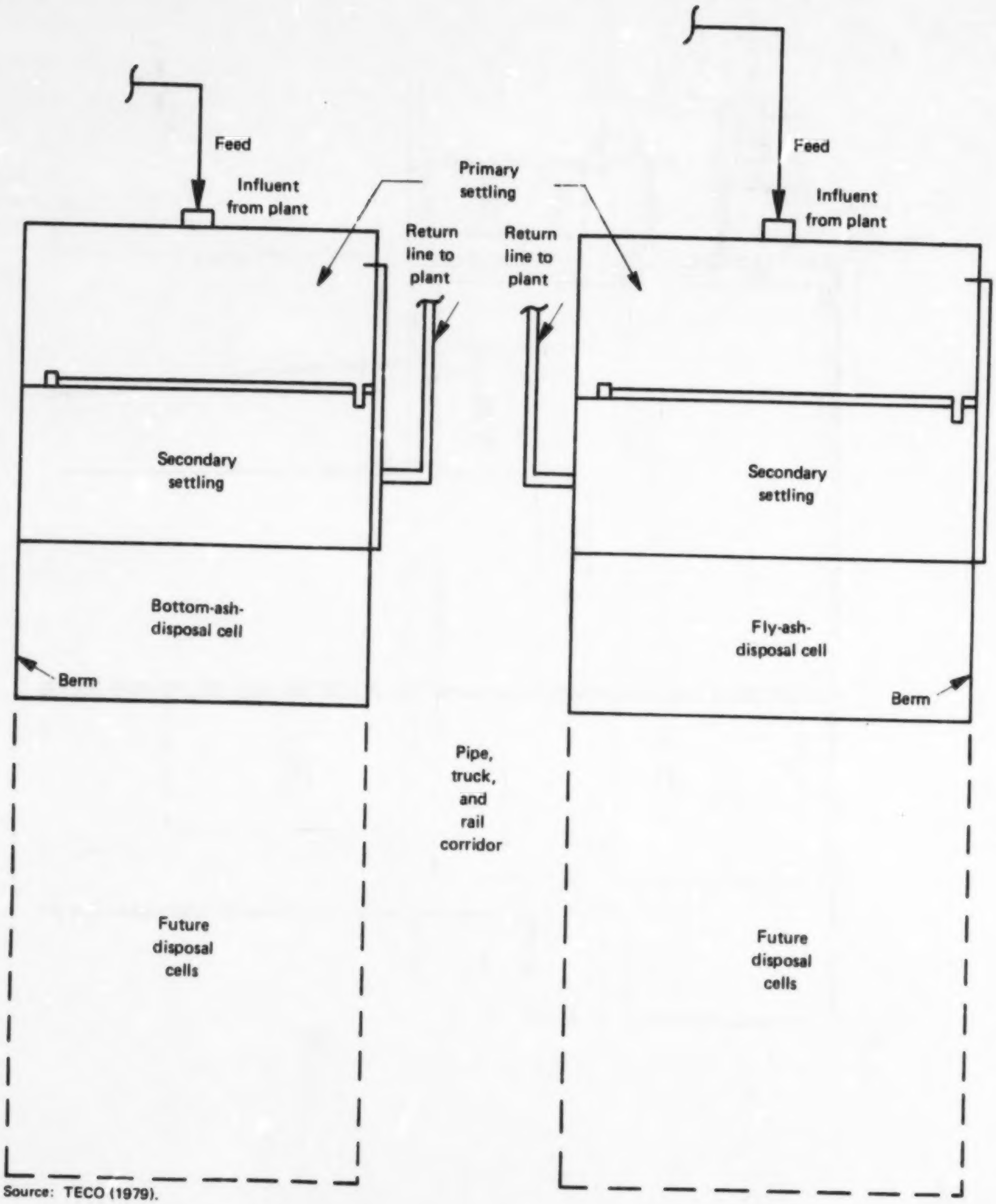

Boiler
Overfire airports
Burners
Bottom ash
Secondary air
Flue gas @~600°F
Air heater
Flue gas @~267°F
Ambient air
FD fan
Primary air
Coal
Pulverizer
Electrostatic precipitator
Fly ash
Ash disposal
ID fan
Booster fan
Flue gas bypass
FGD system
Ambient air
Reheat system
Flue gas @~156°F
Stack
To FGD sludge treatment system
FGD Flue-gas desulfurization
ID Induced draft
FD Forced draft

Figure 4-12. Flow diagram of combustion system and air-pollution control system at Big Bend Station.


Pressure relief duct
Steam from
50-psig header
Indirect
reheater
Ambient
air
Reheater
fan
Condensate
drum
Flue gas
to stack
Mist
eliminator
Wetted film
contactor
Spray
tower
Liquid/gas
separator
Quencher
Fan from
precipitator
Booster fan
Precipitator
Quencher
pump
Forced
oxidation
compressor
Pump
seal
water
Makeup
water
Liquid
cyclone
Absorber
pump
Tank
absorber
feed
Reagent
feed pump
Limestone
reagent
feed tank
Limestone
from truck
Limestone
stacker
conveyor
Limestone storage pile
Limestone
reclaimer
conveyor
Limestone
day silo
Liquid
cyclone
Weigh feeder
Ball mill
Reclaim water
Limestone slurry
transfer pump
Limestone slurry
transfer pump
Liquid cyclone
dewatering
Reclaim
water tank
Reclaim
water pump
Sludge
underflow
tank
Vacuum
filter
feed
pump
Vacuum filter
Filtrate
return
water
Chloride
bleed stream

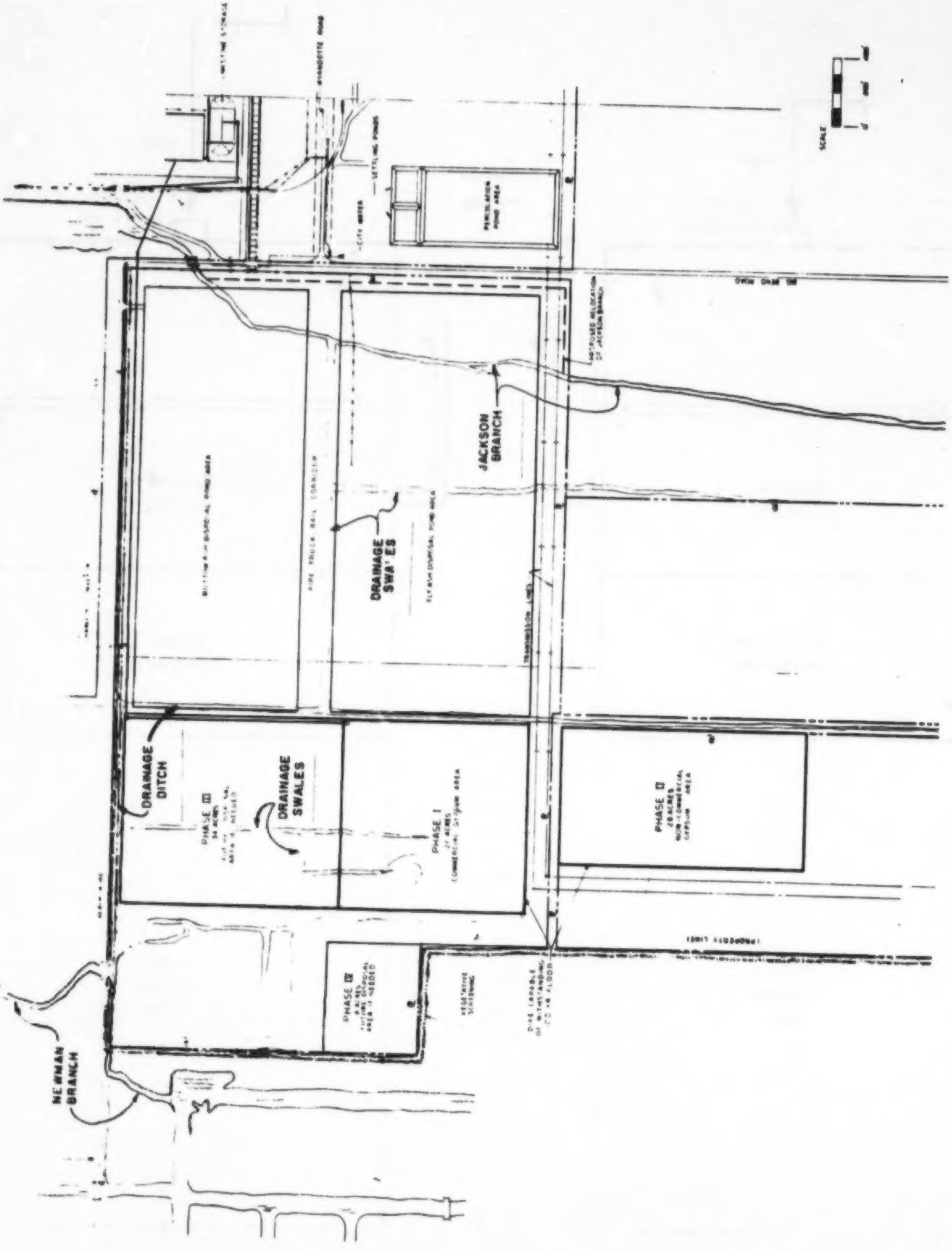
Source: TECO (1980a).

Figure 4-13. Limestone flue-gas-desulfurization system at Big Bend Station.


Feed
Influent from plant
Primary settling
Return line to plant
Return line to plant
Feed
Influent from plant
Secondary settling
Secondary settling
Bottom-ash-disposal cell
Fly-ash-disposal cell
Berm
Berm
Pipe, truck, and rail corridor
Future disposal cells
Future disposal cells

Source: TECO (1979).

Figure 4-14. Conceptual design of the bottom-ash disposal pond and the fly-ash disposal pond, Big Bend Station.


DRAINAGE DITCH
DRAINAGE SWALES
DRAINAGE SWALES
JACKSON BRANCH
NEWMAN BRANCH
PHASE I
PHASE II
PHASE III
PHASE III
SCALE

Source: Tampa Electric Company (1980).

Figure 4-15. Bottom-ash, fly-ash and flue-gas-desulfurization areas, Big Bend site.

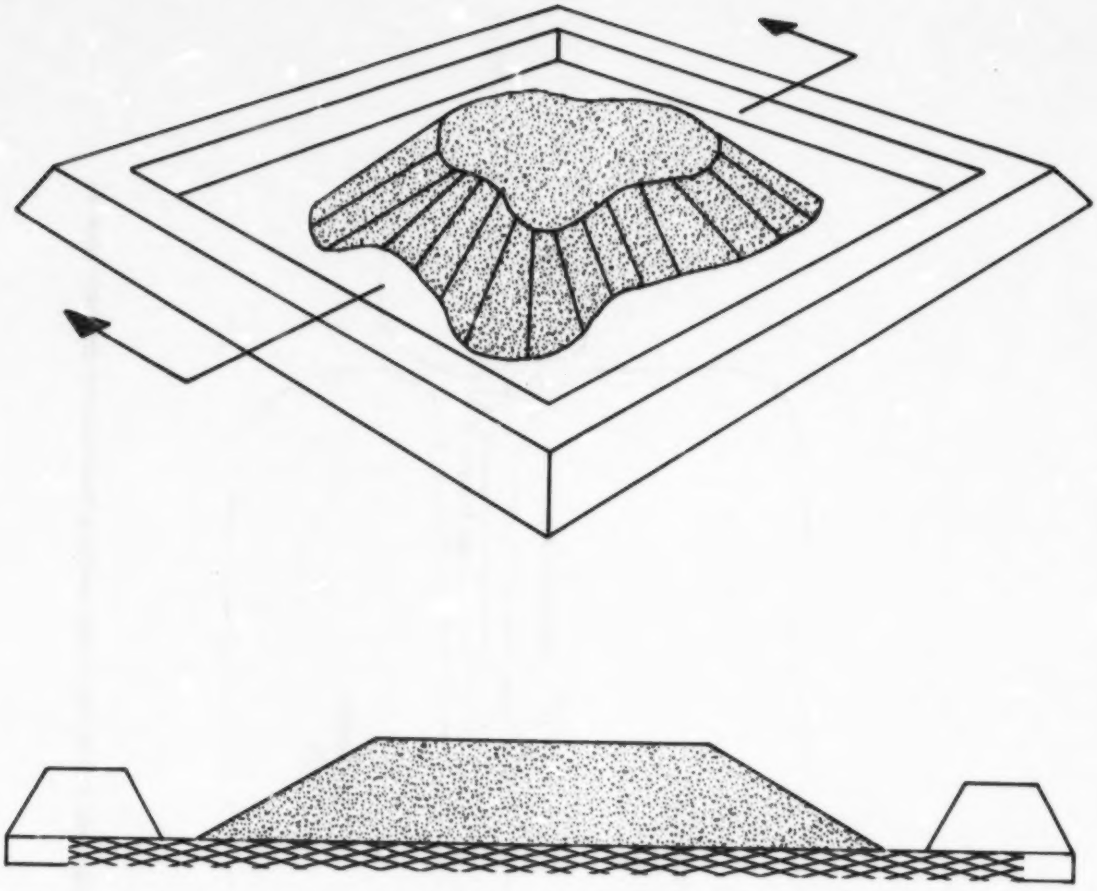


Figure 4-16. Heaped-fill configuration for storage of flue-gas-desulfurization by-product gypsum, Big Bend Station.

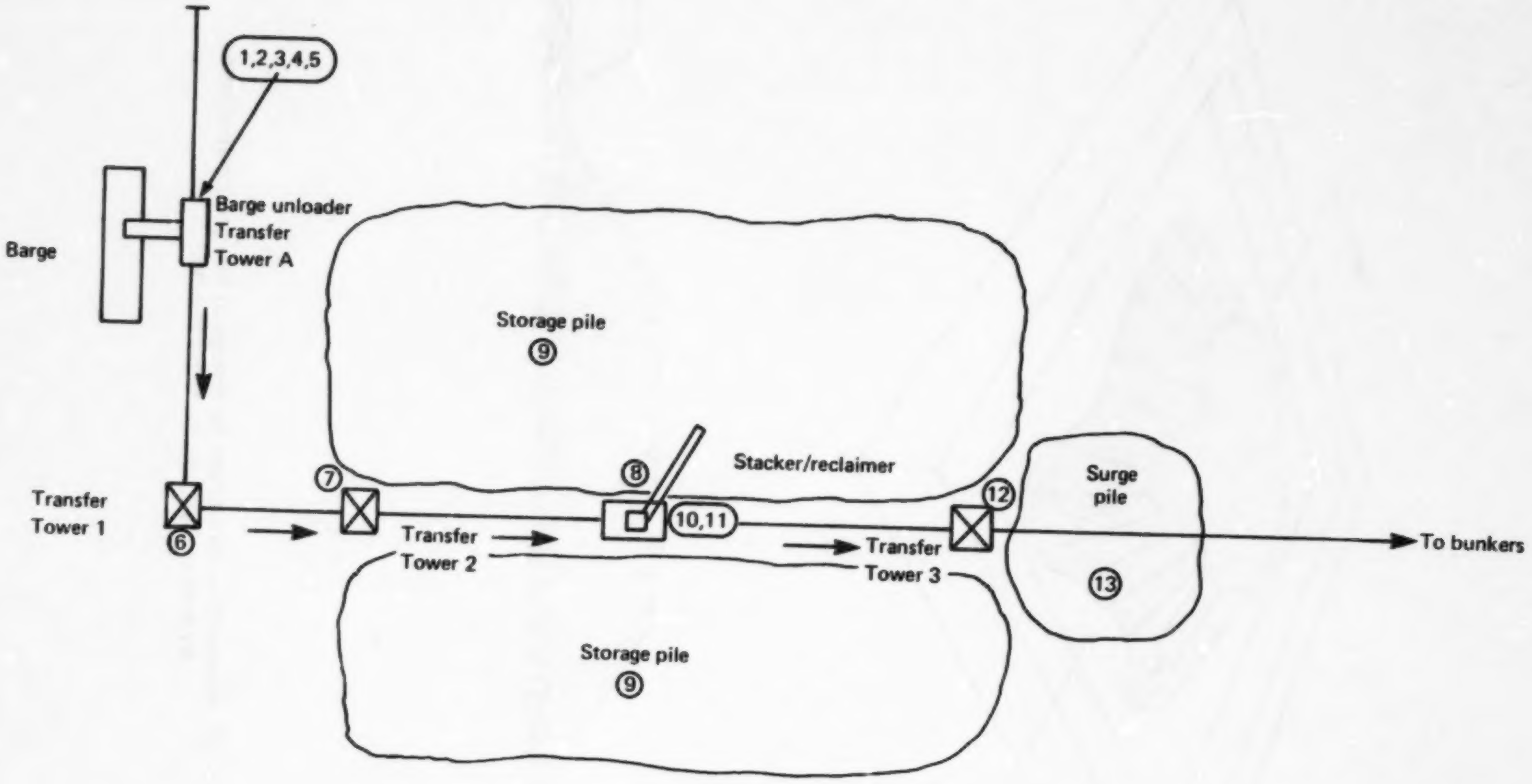

1,2,3,4,5
Barge
Barge unloader
Transfer
Tower A
Storage pile
⑨
Stacker/reclaimer
⑦
⑧
Transfer
Tower 1
⑥
Transfer
Tower 2
10,11
Transfer
Tower 3
⑫
Surge
pile
⑬
To bunkers
Storage pile
⑨

Figure 4-17. Schematic of Big Bend coal-handling facilities and emission sources.

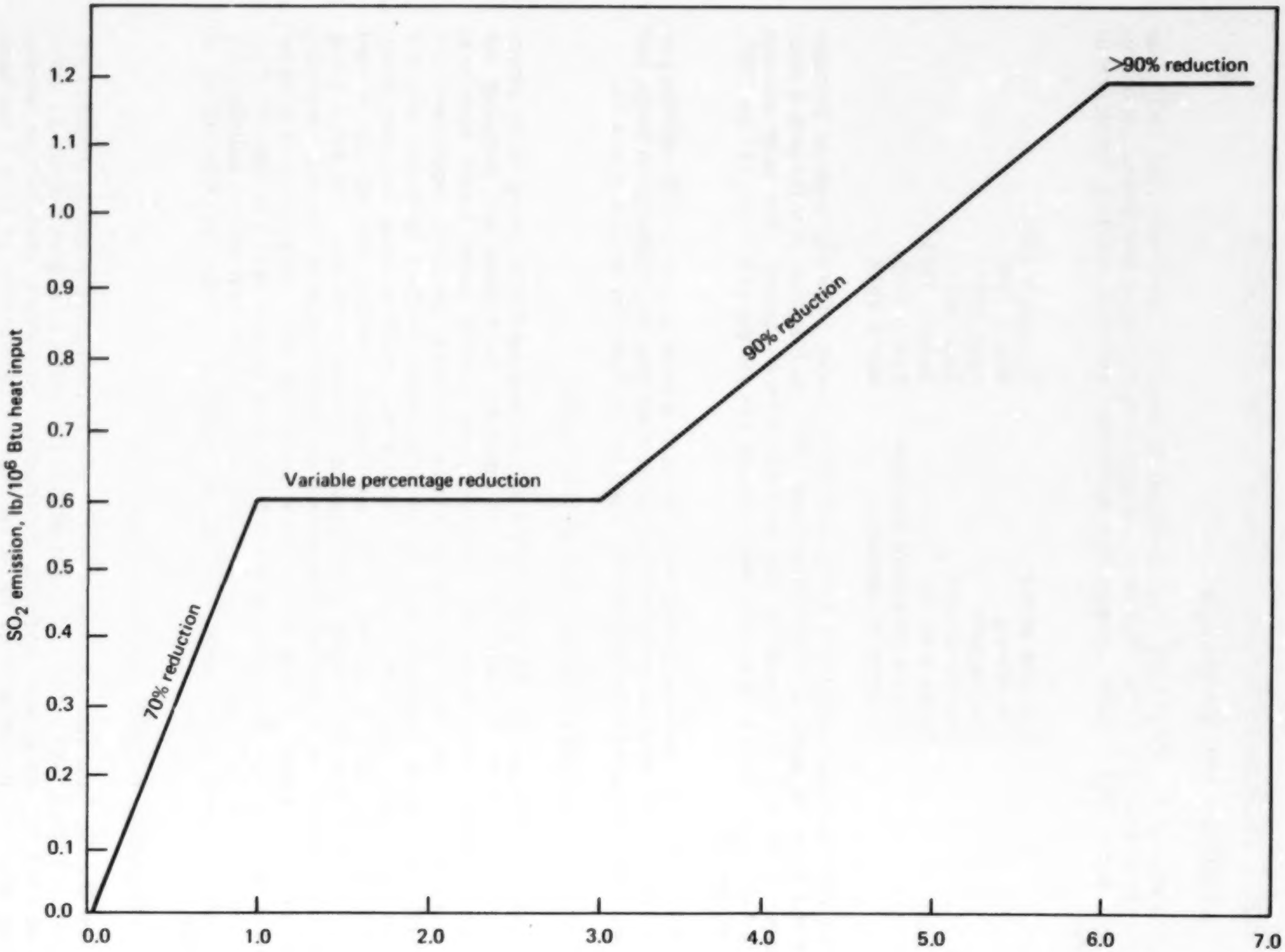


Figure 4-18. SO$_2$ percentage reduction standard.

4.3 CONSTRUCTION SCHEDULE, FACILITIES, AND MANPOWER

4.3.1 SCHEDULE AND MANPOWER

Construction of Big Bend Unit 4 is scheduled to begin in November 1981 and to be completed in February 1985. The unit is expected to be placed in commercial operation in March 1985. Major construction activities and their starting dates are as follows:

Site preparation	November 1981
Pile driving	March 1982
Foundations	April 1982
Structural steel	July 1982
Boiler erection	January 1983
Turbine-generator erection	March 1983
Commercial operation	March 1985

The number of persons employed in the construction work force will show an increasing trend from the start of construction until 1984. In that year it will reach a peak of about 1,100 and will remain at this level for several months. The daily average number of construction workers is expected to be 184 for the year 1982, 487 for 1983, and 860 for 1984.

Traffic to and from the site is estimated to reach a peak in 1984 of 550 vehicles per day, which includes vehicles of the construction companies, the construction force, and visitors. This compares to a daily vehicle count of 1,800 per day on U.S. Route 41.

4.3.2 CONSTRUCTION OF MAJOR PLANT FACILITIES

Construction activities for Big Bend Unit 4 will encompass the following major structures and equipment: the boiler and boiler complex; the turbine hall, including the turbine, condenser, and feedwater equipment; the cooling water intake structure; the precipitators and flue gas desulfurization facilities, including equipment for handling and storing limestone and the desulfurization product (gypsum); and the systems for handling ash from the boiler. Unit 4 will utilize existing facilities (those currently serving Units 1, 2, and 3) for the receipt, handling, and storage of coal and for the handling and treatment of liquid and sanitary wastes. The ash-settling ponds and disposal cells will be constructed on TECO property currently occupied by an unused U-shaped cooling pond. These ponds will allow recycling of the water used for ash sluicing. The building site for Unit 4 is an area that was used for construction of Units 1, 2, and 3. It is presently occupied by maintenance buildings for those units. These maintenance buildings will either be eliminated or relocated at the site.

4.3.3 TEMPORARY CONSTRUCTION FACILITIES

Land on the Big Bend site adjacent to Unit 4 will be used temporarily to support construction. Figure 4-14 shows the construction site layout. Approximately 41 acres will be used for equipment laydown, construction workshops, construction worker parking, etc. All of the acreage to be used during construction of Unit 4 has been previously disturbed by construction activities associated with Units 1, 2, and 3. It contains primarily herbaceous, low-growing vegetation typical of disturbed areas in the early stages of secondary succession.

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Tampa Electric Company. 1981. Site certification application, Big Bend Unit 4, Amendment 5.

Teplitzky, A. M., and Wood, E. W. 1978. Power plant construction noise emission. In Proceedings of the 1978 international conference on noise control engineering, ed. W. Lang. Noise Control Foundation, Poughkeepsie, New York, p. 279.

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U.S. Environmental Protection Agency. 1978. Guidelines for the evaluation of BACT.